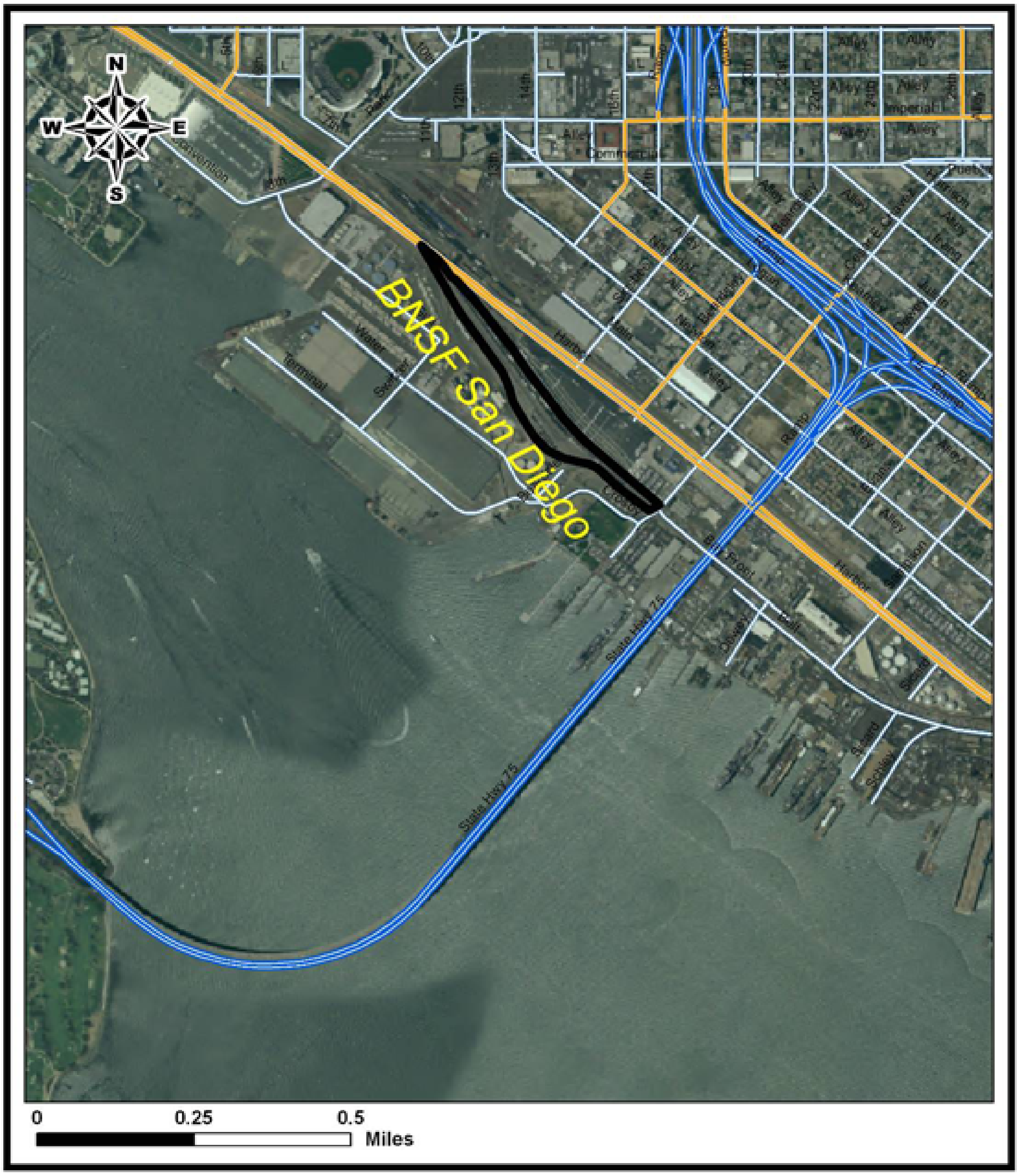
California Environmental Protection Agency

Air Resources Board

Health Risk Assessment for the BNSF Railway San Diego Railyard



Stationary Source Division

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I. INTRODUCTION

The California Air Resources Board (ARB or Board) conducted a health risk assessment study (study) to evaluate the impacts from airborne particulate matter emissions from diesel-fueled engines associated with activities at BNSF Railway's (BNSF) San Diego Railyard, located approximately one mile southeast of downtown San Diego. The study focused on the railyard property emissions from locomotives, off-road vehicles, and transport refrigeration units (TRUs). Also evaluated were mobile and stationary sources with significant emissions within an off-site boundary of one mile distance from the railyard. This information was used to evaluate the potential health risks associated with diesel particulate matter emissions to those living nearby the railyard.

A. Why ARB is concerned about diesel PM emissions?

In 1998, following a 10-year scientific assessment process, ARB identified particulate matter from diesel exhaust (diesel PM) as a toxic air contaminant based on its potential to cause cancer and other adverse health problems, including respiratory illnesses and increased risk of heart disease. Subsequent research has shown that diesel PM contributes to premature death[1] (ARB, 2002). Exposure to diesel PM is a health hazard, particularly to children, whose lungs are still developing; and the elderly, who may have other serious health problems. In addition, the diesel PM particles are very small. By mass, approximately 94% of these particles are less than 2.5 microns in diameter ($PM_{2.5}$). Because of their tiny size, diesel PM particles are readily respirable, and can penetrate deep into the lung and enter the bloodstream, carrying with them an array of toxins. Population-based studies in hundreds of cities in the U.S. and around the world demonstrate a strong link between elevated PM levels and premature deaths (Pope et al., 1995, 2002 and 2004; Krewski et al., 2000), increased hospitalizations for respiratory and cardiovascular causes, asthma and other lower respiratory symptoms, acute bronchitis, work loss days, and minor restricted activity days (ARB, 2006a).

Diesel PM emissions are the dominant toxic air contaminants in and around a railyard facility. Statewide, diesel PM accounts for about 70% of the estimated potential ambient air toxic cancer risks, based on an analysis conducted by ARB staff in 2000 (ARB, 2000). Based on scientific research findings and the dominance of diesel PM emissions, the health impacts in this study primarily focus on the risks from the diesel PM emissions.

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[1] Premature Death: as defined by U.S. Centers for Disease Control and Prevention's *Years of Potential Life Lost*, any life ended before age 75 is considered as premature death.

B. Why evaluate diesel PM emissions at the BNSF San Diego Railyard?

In 2005, the ARB entered into a statewide railroad pollution reduction agreement (Agreement) with Union Pacific Railroad (UP) and BNSF Railway (BNSF) (ARB, 2005) This Agreement was developed to implement near-term measures to reduce diesel PM emissions in and around California railyards by approximately 20%.

The Agreement requires that health risk assessments (HRAs) be prepared for each of the 17 major or designated railyards in the State. The Agreement requires the railyard HRAs to be prepared based on the experience of the UP Roseville Railyard HRA study in 2004 (ARB, 2004a) and the *ARB Health Assessment Guidance for Railyards and Intermodal Facilities* that the ARB staff developed in 2006 (see http://www.arb.ca.gov/railyard/hra/hra.htm) (ARB, 2006b). The BNSF San Diego Railyard is one of the designated railyards subject to the Agreement and the health risk assessment requirements.

C. What are Health Risk Assessments (HRAs)?

An exposure assessment is an analysis of the amount (i.e., concentration in the air) of a pollutant that a person is exposed to for a specific time period. This information is used in a risk assessment to evaluate the potential for a pollutant to cause cancer or other health effects. An HRA uses mathematical models to evaluate the health impacts from exposure to certain chemical or toxic air contaminants released from a facility or found in the air. HRAs provide information to estimate potential long-term cancer and non-cancer health risks. HRAs do not gather information or health data on specific individuals, but are estimates for the potential health impacts on a population at large.

An HRA consists of three major components: (1) the air pollution emission inventory, (2) the air dispersion modeling, and (3) an assessment of associated health risks. The air pollution emission inventory provides an understanding of how the air toxics are generated and emitted. The air dispersion modeling incorporates the estimated emission inventory and meteorological data as inputs, then use a computer model to predict the distributions of air toxics in the air. Based on this information, an assessment of the potential health risks from the air toxics to an exposed population is performed. The results are expressed in a number of ways as summarized below.

- For potential cancer health effects, the risk is usually expressed as the number of chances in a population of a million people. The number may be stated as “10 in a million” or “10 chances per million”. The methodology used to estimate the potential cancer risks is consistent with the Tier-1 analysis of *Air Toxics Hot Spots Program Risk Assessment Guidelines* (OEHHA, 2003). A Tier-1 analysis assumes that an individual is exposed to an annual average concentration of a given pollutant continuously for 70 years. The length of time that an individual is exposed to a given air concentration is proportional to the risk. During childhood, the impact from exposure to a given air concentration is greater. Exposure durations of 30 years or 9 years may also be evaluated as supplemental information to present the range of cancer risk based on residency period.

- For non-cancer health effects, a reference exposure level (REL)[2] is used if there will be certain identified adverse health impacts, such as lung irritation, liver damage, or birth defects. These adverse health effects may happen after chronic (long-term) or acute (short-term) exposure. To calculate a non-cancer health risk number, the reference exposure level is compared to the concentration to which a person is exposed, and a hazard index is calculated. The higher the hazard index is above 1, the greater the potential for possible adverse health effects. If the hazard index is less than 1, it is an indicator that adverse effects are less likely to occur.

- For premature deaths linked to diesel PM emissions in the San Diego Air Basin, ARB staff estimated about 420 premature deaths per year due to diesel exhaust exposure in 2000 (ARB Research Division, and Lloyd and Cackette, 2001). The total diesel PM emission from all sources in the San Diego Air Basin is about 1,800 tons per year in 2005 (ARB, 2006c). The total diesel PM emissions from the BNSF San Diego Railyard, on the other hand, are an estimated 1.7 tons for the year 2005, or about 0.1% of total air basin diesel PM emissions.

The potential cancer risk from a given carcinogen estimated from the health risk assessment is expressed as the incremental number of potential cancer cases that could be developed per million people, assuming the population is exposed to the carcinogen at a constant annual average concentration over a presumed 70-year lifetime. The ratio of the potential number of cancers per million people can also be interpreted as the incremental likelihood of an individual exposed to the carcinogen developing cancer from continuous exposure over a lifetime. For example, if the cancer risk were estimated to be 100 chances per million, then the probability of an individual developing cancer would not be expected to exceed 100 chances in a million. If a population (e.g., one million people) were exposed to the same potential cancer risk (e.g., 100 chances per million), then statistics would predict that no more than 100 of

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[2] The reference exposure level for diesel PM is essentially the U.S. EPA Reference Concentration first developed in the early 1990s based on histological changes in the lungs of rats. Since the identification of diesel PM as a toxic air contaminant, California has evaluated the latest literature on particulate matter health effects to set the Ambient Air Quality Standard. Diesel PM is a component of particulate matter. Health effects from particulate matter in humans include illness and death from cardiovascular and respiratory disease, and exacerbation of asthma and other respiratory illnesses. Additionally, a body of literature has been published, largely after the identification of diesel PM as a toxic air contaminant and adoption of the reference exposure level, which shows that diesel PM can enhance allergic responses in humans and animals. Thus, it should be noted that the reference exposure level does not reflect adverse impacts of particulate matter on cardiovascular and respiratory disease and deaths, exacerbation of asthma, and enhancement of allergic response.

those million people exposed would be likely to develop cancer from a lifetime of exposure (i.e., 70 years) due to diesel PM emissions from a facility.

The HRA is a complex process that is based on current knowledge and a number of assumptions. However, there is a certain extend of uncertainty associated with the process of risk assessment. The uncertainty arises from lack of data in many areas, necessitating the use of assumptions. The assumptions used in the assessment are often designed to be conservative on the side of health protection in order to avoid underestimation of risk to the public. As indicated by the OEHHA Guidelines, the Tier-1 evaluation is useful in comparing risks among a number of facilities and similar sources. Thus, the risk estimates should not be interpreted as a literal prediction of disease incidence in the affected communities, but more as a tool for comparison of the relative risk between one facility and another. Therefore, risk assessment results are best used for comparing potential risks to target levels to determine the level of mitigation needed. They are also an effective tool for determining the impact a particular control strategy will have on reducing risks.

As soon as the HRAs are final, both the ARB and BNSF, in cooperation with the San Diego AQMD staff, local citizens, and others, will begin a series of meetings to identify and implement measures to reduce emissions from railyard sources. Existing effects are detailed in Section C of Chapter III.

D. Who prepared the BNSF San Diego Railyard HRA?

Under the Agreement, ARB worked with affected local air quality management districts, counties, cities, communities, and the two railroads to develop two guideline documents for performing the health risk assessments. The two documents, entitled *ARB Rail Yard Emissions Inventory Methodology* (ARB, 2006e) and *ARB Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006b), provide guidelines for the identification, modeling, and evaluation of the toxic air contaminants from designated railyards throughout California.

Using the guidelines, BNSF and their designated consultant (i.e., ENVIRON International Corporation) were responsible for the preparation of the emission inventories and performing the air dispersion modeling for operations that occur within the BNSF San Diego Railyard. The base year of the analysis is 2005.

ARB staff is responsible for reviewing and approving the railroads' submittals, identifying significant sources of emissions near the railyards and modeling the impacts of those sources, and preparing the railyard health risk assessments. ARB staff is also responsible for releasing the draft HRAs to the public for comment and presenting them at community meetings. After reviewing public comment on the draft HRAs, ARB staff made revisions as necessary and appropriate, and is now presenting the HRAs in final form.

Ultimately, the information derived from the railyard HRAs is to be used to help identify the most effective mitigation measures that could be implemented to further reduce railyard emissions and public health risks.

E. How is this report structured?

The next chapter provides a summary of the BNSF San Diego Railyard operations, emissions, air dispersion modeling, and health risk assessment results. Following the summary, the third chapter presents the details of the BNSF San Diego Railyard emission inventories. After that, the fourth chapter explains how the air dispersion modeling was conducted, and the fifth chapter provides the detailed health risk assessment for the BNSF San Diego Railyard. The appendices present the technical supporting documents for the analyses discussed in the main body of the report.

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II. SUMMARY

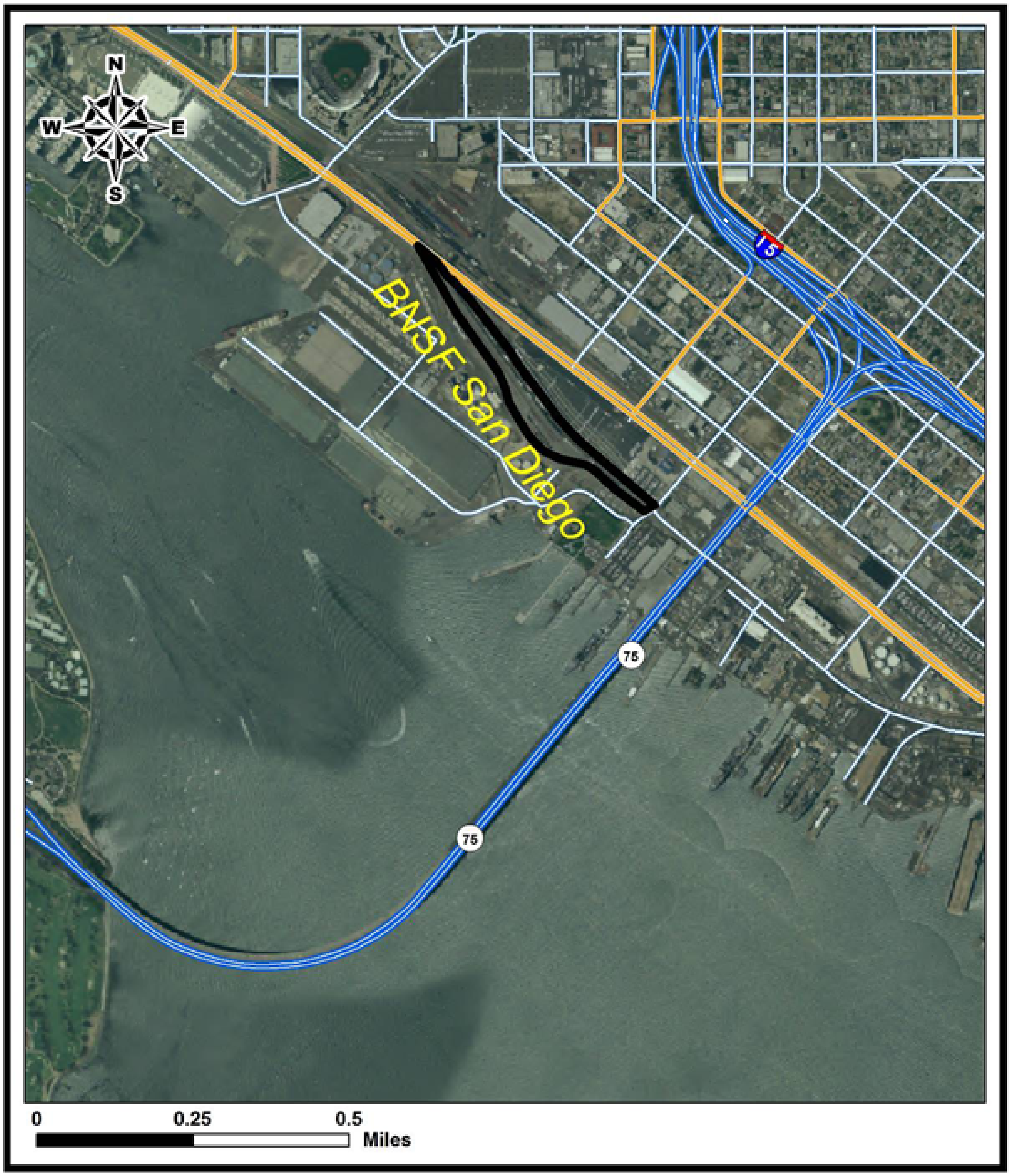
Below is a summary of the BNSF Railway's (BNSF) San Diego Railyard operation activities, emissions, and air dispersion modeling, and health risk assessment results.

A. General Description of the BNSF San Diego Railyard and the Surrounding Areas

The BNSF San Diego Railyard is a smaller BNSF-operated railyard in the vicinity of San Diego Harbor. The location of the railyard is approximately one mile southeast of downtown San Diego, and about 500 feet inland of the San Diego Bay. The railyard is bordered to the north and east by East Harbor Drive, to the west by Beardsley Street, and to the south by the Cesar E. Chavez Parkway. The railyard's configuration is from northwest to southeast, with a length of approximately 3,000 feet and a width of approximately 300 feet. The administration building and street entrance are located at 1342 Cesar E. Chavez Parkway, San Diego, California, 92113 (ENVIRON, 2008a: hereinafter referred to as the ENVIRON Report). As shown in Figure II-1, the facility is located in a commercial and manufacturing area with several residential areas located within one mile.

There are two major freeways within a mile of the railyard: Interstate 5 (I-5), located about 2000 feet to the northeast and State Route 75 (SR-75), located about 500 feet to the southeast (See Figure II-1).

Figure II-1: BNSF San Diego Railyard and Surrounding Areas



B. What are the primary facility operations at the BNSF San Diego Railyard?

The primary facility operations at the BNSF San Diego Railyard are detailed in the ENVIRON Report.

The main purpose of the BNSF San Diego Railyard is to make up trains. Making up trains is the process of breaking up arriving trains into railcars (representing a collection of cars or a piece of a train) and compiling of railcars to complete trains for departure.

The railcars are moved within the railyard to form trains by switching locomotives. A total of four switchers operate at the BNSF San Diego Railyard. The switchers operate on both ends of the railyard and partially outside the railyard's boundaries. The center of the railyard is used mainly for railcar parking. Ready trains will leave the yard north-eastward. Two trains are made-up at the BNSF San Diego Railyard per day. There is an additional train that passes through the yard each day with no change to the railcar configuration. Therefore, a total of three trains arrive in the BNSF San Diego Railyard per day, for a total of about 1,100 trains per year.

The movement of railcars and assembly of trains is the only significant activity at the BNSF San Diego Railyard. No cargo handling operation occurs within the railyard. The railcars are loaded and unloaded elsewhere.

The make-up of trains and their departure, as well as the passing of complete trains, are the most significant locomotive activities at the BNSF San Diego Railyard. The engine-on locomotive operations include switching activities, arriving and departing trains, as well as their maneuvering activities within the classification yard. There are no passing train activities. Service activities are limited to a small amount of locomotive refueling. About every four days, a switcher engine is refueled at one of the two direct to locomotive (DTL) or truck to locomotive fueling sites. There are no locomotive inspections performed at the BNSF San Diego Railyard.

C. What are the diesel PM emissions at and near the BNSF San Diego Railyard?

In 2005, the combined diesel PM emissions from the BNSF San Diego Railyard (on-site emissions) and other significant emission sources within a one-mile distance (off-site emissions) are estimated at about 13.3 tons per year. Off-site sources and activities – not generally related to activities at the railyard – within a one mile distance from the railyard were estimated at about 11.6 tons per year, or about 87% of the combined on-site and off-site diesel PM emissions. The diesel PM emissions at the BNSF San Diego Railyard are estimated at about 1.7 tons per year, or about 13% of the combined on-site and off-site diesel PM emissions.

To provide a perspective on the railyard diesel PM emissions, Table II-1 summarizes three major diesel PM source categories (for the year 2005) within all designated railyards subject to the health risk assessments under the 2005 agreement.

Table II-1: Comparison of Diesel PM Emissions from Eighteen Railyards (Tons Per Year)

Railyard	Locomotives	Cargo Handling Equipment	On-Road Trucks	Others (Off-Road Equipment, Transport Refrigeration Units, Stationary Sources, etc.)	Total†
BNSF Barstow	27.1	0.03	0.04	0.75	**27.9**
BNSF San Bernardino	10.6	3.7	4.4	3.4	**22.0**
BNSF San Diego	1.6	N/A	0.007	0.04	**1.7**
UP ICTF/Dolores	9.8	4.4	7.5	2	**23.7**
UP Colton	16.3	N/A	0.2	0.05	**16.5**
UP Oakland	3.9	2.0	1.9	3.4	**11.2**
UP City of Industry	5.9	2.8	2	0.2	**10.9**
UP Roseville*	25.1	N/A‡	N/A	N/A	**25.1**
BNSF Hobart	5.9	4.2	10.1	3.7	**23.9**
UP Commerce	4.9	4.8	2	0.4	**12.1**
UP LATC	3.2	2.7	1	0.5	**7.3**
UP Stockton	6.5	N/A	0.2	0.2	**6.9**
UP Mira Loma	4.4	N/A	0.2	0.2	**4.8**
BNSF Richmond	3.3	0.3	0.5	0.6	**4.7**
BNSF Stockton	3.6	N/A	N/A	0.02	**3.4**
BNSF Commerce Eastern	0.6	0.4	1.1	1	**3.1**
BNSF Sheila	2.2	N/A	N/A	0.4	**2.7**
BNSF Watson	1.9	N/A	< 0.01	0.04	**1.9**

* The UP Roseville Health Risk Assessment (ARB, 2004a) was based on 1999-2000 emission estimate, only locomotive diesel PM emissions were reported in that study. The actual emissions were estimated at a range of 22.1 to 25.1 tons per year.

‡ N/A: Not applicable. † Number s may not add precisely due to rounding.

1. Railyard Emissions

The BNSF San Diego Railyard emission sources include, but are not limited to, locomotives, off-road diesel-fueled equipment, on-road trucks, and transport refrigeration units (TRUs). The facility operates 24 hours per day, 365 days per year. The BNSF San Diego Railyard emissions were calculated on a source-specific and facility-wide basis for the 2005 baseline year (ENVIRON Report). The future growth in emissions at the BNSF San Diego Railyard is not incorporated in the HRA emission inventory, but will be included as part of the mitigation efforts. The methodology used to calculate the diesel PM and other TAC emissions is based on the *ARB Railyard Emission Inventory Methodology* (ARB, 2006e). The locomotive emission factors used in the study are presented in Appendix D.

Within the BNSF San Diego Railyard facility, 98% of total diesel PM emissions were estimated to be generated from locomotive operations, at about 1.63 tons per year. The locomotive diesel PM emissions are primarily due to arrivals and departures, comprising about 1.47 tons per year. Railway operations, consisting of switching and refueling, contribute 0.16 tons per year (ENVIRON Report).

The remaining 2% of BNSF San Diego Railyard diesel PM emissions are generated by the off-road equipment and transport refrigeration equipment, at 0.04 tons per year (ENVIRON Report).

The diesel PM emissions at the railyard are categorized in Table II-2.

Table II-2: BNSF San Diego Railyard and Surrounding Area Diesel PM Emissions

Diesel PM Emission Sources	BNSF San Diego Railyard		Off-Site Emissions	
	Tons Per Year	**Percentage***	**Tons Per Year**	**Percentage***
LOCOMOTIVES	**1.63**	**98%**	-	-
- Arrivals and Departures	*1.47*	*88%*		
- Switching	*0.16*	*10%*		
- Refueling	*0.005*	*< 1%*		
OFF-ROAD VEHICLES AND EQUIPMENT	**0.02**	**1%**	-	-
TRANSPORT REFRIGERATION EQUIPMENT	**0.02**	**1%**	-	-
OFF-SITE MOBILE SOURCES	-	-	**6.0**	**52%**
OFF-SITE STATIONARY SOURCES	-	-	**5.6**	**48%**
TOTAL	**1.67**	**100%**	**11.6**	**100%**

* Numbers may not add precisely due to rounding.

Diesel PM is not the only toxic air contaminant (TAC) emitted in the BNSF San Diego Railyard. Relatively small amounts of other toxic air contaminants are emitted from gasoline, liquefied petroleum gas (LPG), and compressed natural gas (CNG) operations in the railyard. The total organic gases are estimated at about 0.01 tons per year, or 30 pounds per year, compared to 1.67 tons per year of diesel emissions in the railyard.

The total organic gases are speciated according to ARB Speciate Profile #2105 for exhaust emissions and ARB Speciate Profile #422 for evaporative emissions. Most of the toxic air contaminants in the total organic gases are not identified as carcinogen according to the OEHHA Guidelines (OEHHA, 2003). When the exhaust and evaporative emissions profiles are combined, benzene, formaldehyde, and 1,3-butadiene are the only toxic air contaminants among the top five cancer contributors, and total about 0.7 pounds per year. Calculation of potency weighted emissions for the on-site toxic air contaminants (see a similar analysis for off-site contaminants in Table II-3) shows a substantially lower level of potential cancer risk, about a factor of 38,000 less than the cancer risk level for diesel PM. Hence, only diesel PM emissions are presented in the on-site emission analysis.

2. Surrounding Sources

ARB staff also evaluated significant mobile and stationary sources of diesel PM emissions within a one-mile distance of the BNSF San Diego Railyard. A one-mile distance was chosen because the Health Risk Assessment study for the UP Roseville Railyard (ARB, 2004a) indicated that cancer risks associated with on-site diesel PM emissions are substantially reduced beyond a one-mile distance from the railyard. Diesel PM emissions from sources operating around the railyard are summarized in Table II-2.

ARB staff analyzed the significant off-site emission sources based on two categories: mobile and stationary. For the off-site mobile on-road sources, the analysis focused on on-road heavy-duty diesel trucks, as these are the primary source of diesel PM from the on-road vehicle fleet. ARB staff estimated mobile emissions based on roadway specific vehicle activity data and allocated them to individual **roadway links**. All roadway links within a one-mile distance from the BNSF San Diego Railyard are included in the analysis. The estimates do not include the diesel PM emissions generated from other modes such as extended idling, starts, and off-road diesel-fuel equipment outside the railyard. Individual sources such as local truck distribution centers and warehouses were not evaluated due to insufficient source-specific activity data; however, their truck traffic related to these facilities is reflected in the roadway link traffic activities. Because the off-site mobile sources have only focused on the on-road truck diesel emissions, the exclusion of extended idling and off-road equipment may result in an underestimation of off-site mobile sources emissions.

> **Roadway link:** is defined as a discrete section of roadway with unique estimates for the fleet specific population and average speed and is classified as a freeway, ramp, major arterial, minor arterial, collector, or centroid connector.

Off-site diesel PM emissions are divided about evenly between mobile sources, at about 6.0 tons per year; and stationary sources, at about 5.6 tons per year. The off-site mobile and stationary diesel PM emissions total 11.6 tons per year, or about 87% of the combined on-site and off-site diesel PM emissions.

Emissions from off-site stationary source facilities are identified using the California Emission Inventory Development and Reporting System (CEIDARS) database, which contains information reported by the local air districts for stationary sources within their jurisdiction. The CEIDARS facilities whose locations fell within a one-mile distance of the BNSF San Diego Railyard are selected. Diesel PM emissions are estimated from stationary internal combustion engines burning diesel fuel, and operating at stationary sources reported in CEIDARS database. More than 99% of the off-site stationary diesel PM emissions are from two sources: National Steel and Shipbuilding, at 4.1 tons per year; and Southwest Marine Inc., at 1.5 tons per year.

About 40% of the off-site mobile diesel PM emissions comes from diesel-fueled heavy-duty trucks traveling on Interstate 5 (I-5) and State Route 75 (SR-75). The rest of the off-site mobile diesel PM emissions are from diesel-fueled heavy-duty trucks traveling on major local streets.

The diesel PM emissions from the BNSF San Diego Railyard and from the off-site sources within one-mile of the railyard boundary are summarized in Table II-2.

ARB staff also evaluated other toxic air contaminants emissions around the BNSF San Diego Railyard. There are 32 stationary toxic air contaminant sources identified within a one-mile distance of the railyard. The total emissions of toxic air contaminants (other than diesel PM) emitted from these stationary sources were estimated at about 213 tons per year. Over 60 toxic air contaminants are identified among these emissions, in which isopropyl alcohol, n-butyl alcohol, and xylenes are three major contributors with emissions estimated at 74, 63, and 14 tons per year, respectively.

Not all of these toxic air contaminants are identified as carcinogens. According to ARB's *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (ARB, 2000), diesel PM, 1,3-butadiene, benzene, carbon tetrachloride, and formaldehyde are defined as the top five potential cancer risk contributors, based on ambient concentrations. These TACs account for 95% of the State's estimated potential cancer risk levels. This study also concluded that diesel PM contributes over 70% percent of the statewide estimated potential cancer risk levels, significantly higher than other TACs (ARB, 2000). Among the off-site TACs emissions for the BNSF San Diego Railyard, the top five cancer risk contributors other than diesel PM are estimated at about 1.3 tons per year.

The Office of Environmental Health Hazard Assessment (OEHHA) has estimated an inhalation **cancer potency factor (CPF)** for individual chemicals and some chemical mixtures such as whole diesel exhaust. Diesel PM contains many individual cancer causing chemicals. The individual cancer causing chemicals from diesel exhaust are not separately evaluated so as to avoid double counting. The four compounds listed here are given a weighting factor by comparing each compound's CPF to the diesel PM CPF. This factor is multiplied by the estimated emissions for that compound, which gives the cancer potency weighted toxic emission as shown in Table II-3. As seen in Table II-3, the potency weighted toxic emissions for these TACs are de minimis, at about 0.04 tons per year, which is substantially less than the diesel PM emissions.

Cancer potency factors (CPF) are expressed as the 95% upper confidence limit of excess cancer cases occurring in an exposed population assuming continuous lifetime exposure to a substance at a dose of one milligram per kilogram of body weight, and are expressed in units of $(mg/kg\text{-}day)^{-1}$.

In addition, ARB staff evaluated the potential cancer risk levels contributed by the use of gasoline in the San Diego Air Basin. Table II-4 shows the emissions of four primary carcinogen compounds from gasoline exhausts in the San Diego Air Basin in 2005 (ARB, 2006c). As indicated in Table II-4, the cancer potency weighted emissions of these four toxic air contaminants from all types of gasoline sources are estimated at about 209 tons per year, or about 12% of diesel PM emissions in the San Diego Air Basin. If only gasoline-powered vehicles are considered, the potency weighted emissions of these four TACs are estimated at about 100 tons per year, or equivalent to about 6% of diesel PM emissions in the San Diego Air Basin. Hence, gasoline-powered vehicular sources are not included in the analysis.

Table II-3: Potency Weighted Estimated Toxic Emissions From Significant Off-Site Stationary Sources Surrounding the BNSF San Diego Railyard

Toxic Air Contaminant	Cancer Potency Factor	Weighting Factor	Actual Emission (Tons Per Year)	Potency Weighted Toxic Emission (Tons Per Year)
Diesel PM	1.1	1	11.6	11.6
1,3-Butadiene	0.6	0.55	0.001	0.0005
Benzene	0.1	0.09	0.24	0.02
Carbon Tetrachloride	0.15	0.14	0	0
Formaldehyde	0.021	0.02	1.03	0.02
Total (other than diesel PM)			**1.3**	**0.04**

Table II-4: Emissions of Major Toxic Air Contaminants From Use of Gasoline in the San Diego Air Basin

Compound	Toxic Air Contaminant Emissions (Tons Per Year)			
	From All Sources	Potency Weighted*	From Gasoline Vehicles	Potency Weighted*
Diesel PM	1,800	**1,800**	-	-
1,3-Butadiene	190	**104**	97	**53**
Benzene	849	**76**	460	**41**
Formaldehyde	1,240	**25**	250	**5**
Acetaldehyde	497	**4**	72	**0.6**
Total (other than diesel PM)	2,776	**209**	879	**100**

* Based on cancer potency weighting factors.

D. What are the potential cancer risks from the BNSF San Diego Railyard?

As discussed previously, the ARB has developed *Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006b) to ensure that the methodologies used in each railyard HRA meet the requirements for the ARB / Railroad Statewide Agreement. The railyard HRA follows *The Air Toxics Hot Spots Program Risk Assessment Guidelines* published by the Office of Environmental Health Hazard Assessment (OEHHA, 2003), and is consistent with the *Roseville Railyard Study* (ARB, 2004a) performed by ARB staff.

The U.S. EPA's recently approved state-of-science air dispersion model, AERMOD (**A**merican Meteorological Society / **E**PA **R**egulatory Model Improvement Committee **MOD**EL), is used in the ARB railyard health risk assessments. One of the critical inputs required for the air dispersion modeling is meteorological data, such as wind direction and wind speed. These parameters determine where and how the pollutants will be transported.

The BNSF San Diego Railyard does not monitor meteorological variables on site. Wind speed, wind direction, and temperature data from the ARB-operated San Diego-Beardsley Station for 2006 were selected as the most representative available wind speed, wind direction, and temperature data for use in the air dispersion analysis of the BNSF San Diego Railyard. Cloud cover and pressure data from the National Weather Service's San Diego Lindbergh Field for 2006 were used, since the ARB's San Diego-Beardsley Station did not collect pressure measurements in 2006. Upper air data from the San Diego Miramar Naval Air Station were used in AERMET processing for the BNSF San Diego Railyard (ENVIRON, 2008b).

The potential cancer risks from the diesel PM emissions at the BNSF San Diego Railyard are displayed in **isopleths**. For this analysis, ARB staff elected to present the cancer risk isopleths focusing on risk levels of 10, 25, 50, and 100 in a million. Figure II-2 (See Page 18) and Figure II-4 (See Page 24) present these isopleths: Figure II-2 focuses on the near source risk levels, while Figure II-4 focuses on the more regional impacts. In each figure, the risk isopleths are overlaid onto a satellite image of the area surrounding the BNSF San Diego Railyard, to better illustrate the land use (residential, commercial, industrial, or mixed use) of these impacted areas.

> An **isopleth** is a line drawn on a map through all points of equal value of some measurable quantity; in this case, cancer risk.

The OEHHA Guidelines require that for health risk assessments, the cancer risk for the maximum exposure at the point of maximum impact should be reported. The point of maximum impact (PMI), which is defined as a location or the receptor point with the highest cancer risk level outside of the railyard boundary, with or without residential exposure, is predicted to be located at the northeast side of the railyard fence line. The

PMI is downwind of high emission density areas for the prevailing west-northwesterly wind, where about 95% percent of facility-wide diesel PM emissions were generated (See the emission allocation in Appendix E).

The estimated cancer risk at the PMI is about 330 chances per million for the 70-year exposure. The land use in the vicinity of the PMI is primarily zoned for transportation and industrial use. In the residential zoned area, to the northeast of the railyard, the potential cancer risk of maximally exposed individual resident (MEIR) or maximum individual cancer risk (MICR) is estimated at about 70 chances in a million.

As indicated by the *Roseville Railyard Study* (ARB, 2004a), the location of the PMI may vary depending upon the settings of the model inputs and parameters, such as meteorological data set or emission allocations in the railyard. Therefore, given the estimated emissions, modeling settings, and the assumptions applied to the risk assessment, there are great uncertainties associated with the estimation of the PMI and MICR. These indications should not be interpreted as a literal prediction of disease incidence but more as a tool for comparison. In addition, the estimated point of maximum impact location and maximum individual cancer risk value may not be replicated by air monitoring.

ARB staff also conducted a comparison of cancer risks estimated at the PMI versus MICR, and the differences of facility-wide diesel PM emissions between the UP and BNSF railyards. The ratios of cancer risks at the PMI or MICR to the diesel PM emissions do not suggest that one railroad's facilities have statistically higher cancer risks than the other railroad's or vice versa. Rather, the differences are primarily due to emission spatial distributions from individual operations among railyards.

At the BNSF San Diego Railyard property boundaries, the estimated potential cancer risk is about 100 chances per million. As shown in Figure II-2, beyond the railyard boundaries, the estimated potential cancer risks decrease rapidly to about 50 chances per million, and the risks further decrease to 25 in a million within about a mile from the railyard, then to 10 in a million within another mile distance to the southwest.

Figure II-2: Estimated Near-Source Cancer Risk (Chances per Million People) From the BNSF San Diego Railyard

The OEHHA Guidelines recommend a 70-year lifetime exposure duration to evaluate the potential cancer risks for residents. Shorter exposure durations of 30 years and 9 years are also recommended for residents and school-age children, respectively, as a supplement. These three exposure durations – 70 years, 30 years, and 9 years – all assume exposure for 24 hours a day, and 7 days a week. It is important to note that children, for physiological as well as behavioral reasons, have higher rates of exposure than adults on a per unit body weight basis (OEHHA, 2003).

To evaluate the potential cancer risks for off-site workers, the OEHHA Guidelines recommend that a 40-year exposure duration be used, assuming workers have a different breathing rate (149 L kg^{-1} day^{-1}) and exposure for an 8-hour workday, five days a week, 245 days a year.

Table II-5 shows the equivalent risk levels of 70- and 30-year exposure durations for exposed residents; and 40- and 9-year exposure durations for off-site workers and school-aged children, respectively. As Table II-5 shows, the 10 in a million isopleth line in Figure II-4 would become 4 in a million for exposed population with a shorter residency of 30 years, 2.5 in a million for exposed school-age children, and 2 in a million for off-site workers.

To conservatively communicate the risks, ARB staff presents the estimated cancer risk isopleths all based on 70-year resident exposure duration, even for those impacted industrial areas where no resident lives.

Table II-5: Equivalent Potential Cancer Risk Levels for 70-, 40-, and 9-Year Exposure Durations

Exposure Duration (Years)	Equivalent Risk Level (Chance in a million)				
70	10	25	50	100	250
30	4	11	21	43	107
9*	2.5	6.3	12.5	25	63
40‡	2	5	10	20	50

* Exposure duration for school-aged children during the first 9-year childhood.
‡ Exposure duration for off-site workers.

The populated areas near the BNSF San Diego Railyard are primarily located to the northeast of the railyard. Areas located northwest and southeast of the railyard are predominantly commercial/industrial. Southwest of the railyard is the San Diego Harbor. Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated risks above 10 chances in a million levels encompasses approximately

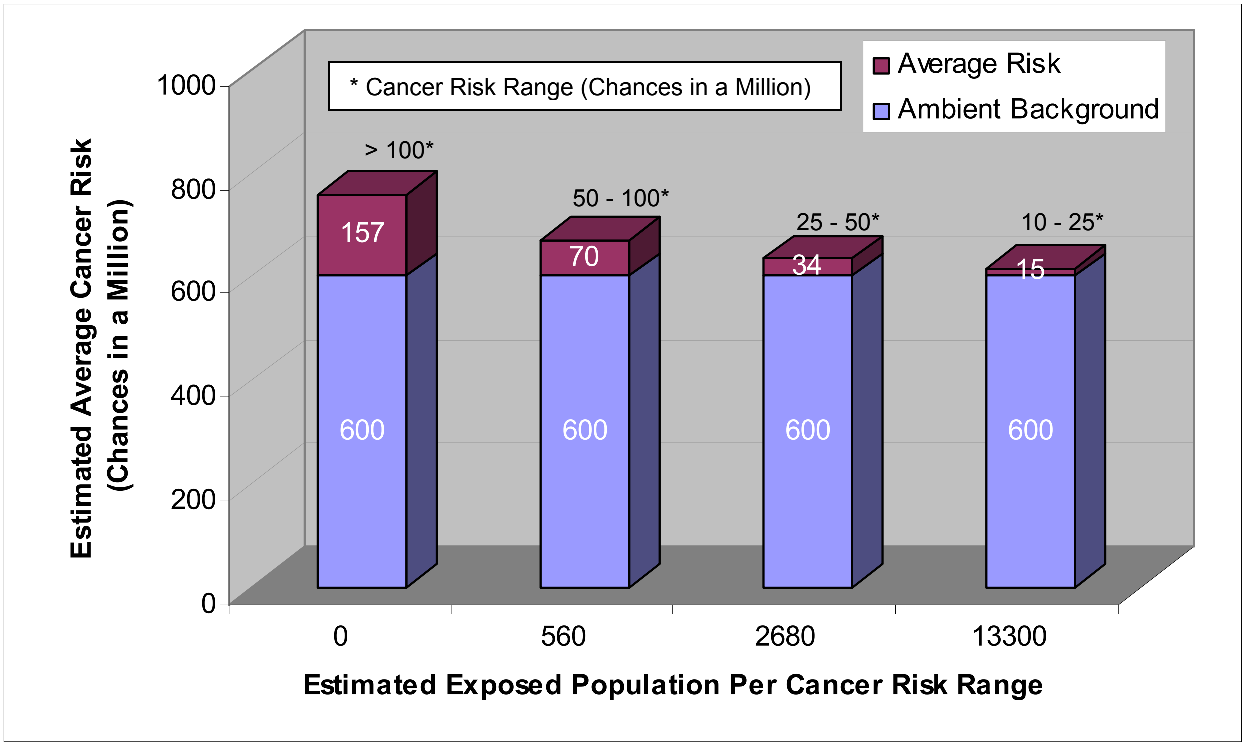
2,250 acres where about 16,500 residents live. Table II-6 presents the exposed population and area coverage size for various impacted zones of cancer risks.

Table II-6: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels (Assumes a 70-Year Exposure)

Estimated Risk (Per Million)	Estimated Impacted Area (Acres)	Estimated Exposure (Population)
10 - 25	1,540	13,300
25 - 50	430	2,680
50 - 100	190	560
> 100	90	0
> 10	**2,250**	**16,500**

It is important to understand that these risk levels represent the predicted risks (due to the BNSF San Diego Railyard diesel PM emissions) above the existing background risk levels. For the broader San Diego Air Basin, the estimated regional background risk level is estimated to be about 600 in a million contributed by all toxic air contaminants in 2000 (ARB, 2006c). Figure II-3 illustrates a comparison of the estimated average potential cancer risks to the regional background cancer risk level. For example, in the cancer risk ranges between 50 and 100 chances per million due to the diesel PM emissions from the BNSF San Diego Railyard, the estimated average potential cancer risk above the regional background is about 70 chances per million. Therefore, residents living in the area with a cancer risk ranging from 50 to 100 chances per million would have a potential cancer risk at about 670 chances per million population.

Figure II-3: Comparison of Estimated Potential Cancer Risks from the BNSF San Diego Railyard and the Regional Background Risk Levels



E. What are the estimated non-cancer chronic risks near the BNSF San Diego Railyard?

The potential non-cancer chronic risk health hazard index levels from the estimated diesel PM emissions from the BNSF San Diego Railyard are estimated to be about 0.10 at the railyard boundary. According to OEHHA Guidelines (OEHHA, 2003), these levels indicate that the potential non-cancer chronic public health risks are less likely to happen.

Due to the uncertainties in the toxicological and epidemiological studies, diesel PM as a whole was not assigned a short-term acute reference exposure level. It is only the specific compounds of diesel exhaust (e.g., acrolein) that independently have potential acute effects (such as irritation of the eyes and respiratory tract), and an assigned acute reference exposure level. However, acrolein is a chemically reactive and unstable compound, and easily reacts with a variety of chemical compounds in the atmosphere.

Compared to the other compounds in diesel exhaust, the concentration of acrolein has a much lower chance of reaching a distant off-site receptor. More importantly, given the multitude of activities ongoing at facilities as complex as railyards, there is a much higher level of uncertainty associated with maximum hourly-specific emission data, which are essential for assessing acute risk. Therefore, non-cancer acute risk is not addressed quantitatively in this study. From a risk management perspective, ARB staff believes it is reasonable to focus on diesel PM cancer risk because it is the predominant risk driver and the most effective parameter to evaluate risk reduction actions. Moreover, actions to reduce diesel PM will also reduce non-cancer risks.

F. What are the estimated health risks from off-site emissions?

ARB staff evaluated the health impacts from off-site pollution sources near the BNSF San Diego Railyard using the U.S. EPA-approved AERMOD dispersion model. Specifically, off-site mobile mobile and stationary diesel PM emission sources located within a one-mile distance from the railyard were included. Off-site diesel PM emissions used in the modeling simulations consisted of about 6.0 tons per year from roadways and 5.6 tons per year from stationary facilities in 2005. The estimated potential cancer risks associated with off-site diesel PM emissions are illustrated in Figure II-5 (See Page 25). As indicated in Figure II-5, the zone of impact of estimated cancer risks associated with off-site diesel PM emissions is much larger as compared to that of the BNSF San Diego Railyard.

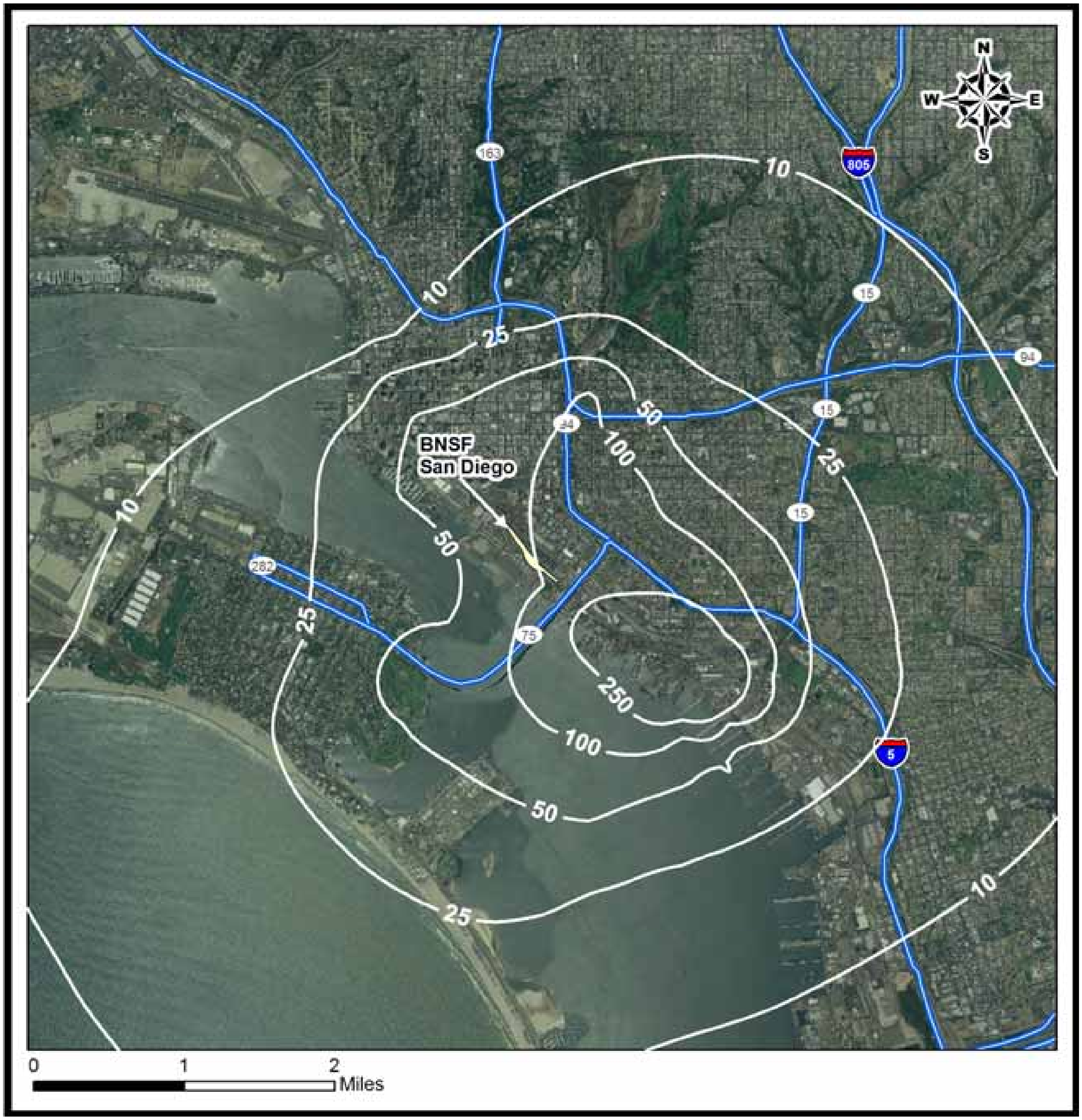
Based on the 2000 U.S. Census Bureau’s data, the zone of impact of the estimated potential cancer risks above 10 chances in a million levels associated with off-site diesel PM emissions encompasses approximately 20,200 acres, where about 160,000 residents live. For comparison with the BNSF San Diego Railyard health risks, the same level of potential cancer risks (more than 10 chances in a million) associated with railyard diesel PM emissions covers about 2,250 acres where approximately 16,500 residents live. Table II-7 presents the exposed population and area coverage size for various impacted zones of potential cancer risks associated with off-site diesel PM emissions.

Table II-7: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels from Off-Site Emissions Near the BNSF San Diego Railyard

Estimated Risk (Per Million)	Estimated Impacted Area (Acres)	Estimated Exposure (Population)
10 - 25	79,400	12,200
25 - 50	41,000	4,100
50 - 100	18,300	2,210
> 100	21,700	1,660
> 10	**160,000**	**20,200**

Figure II-4: Estimated Regional Cancer Risk (Chances Per Million) From the BNSF San Diego Railyard

Figure II-5: Estimated Cancer Risk (Chances Per Million) Near the BNSF San Diego Railyard (Off-Site)



G. Can study estimates be verified by air monitoring?

Currently, there is no approved specific measurement technique for directly monitoring diesel PM emissions in the ambient air. This does not preclude the use of an ambient monitoring program to measure general air quality trends in a region. Since cancer risk is based on an annual average concentration, a minimum of a year of intensive monitoring data would generally be needed.

H. What activities are underway to reduce diesel PM emissions and public health risks?

The ARB has developed a comprehensive approach to reduce statewide locomotive and railyard emissions through a combination of voluntary agreements, ARB and U.S. EPA regulations, funding programs, and early replacement of California's line haul and yard locomotive fleets. California's key locomotive and railyard air pollution control measures and strategies are summarized below:

South Coast Locomotive NO_x Fleet Average Agreement (1998): Signed in 1998 between ARB and both Union Pacific Railroad (UP) and BNSF Railway (BNSF), it requires the locomotive fleets that operate in the South Coast Air Quality Management District (SCAQMD) to meet, on average, U.S. EPA's Tier 2 locomotive emissions standards by 2010. This measure will provide an estimated 65% reduction in oxides of nitrogen (NO_x) and 50% reduction in locomotive particulate matter emissions in the South Coast Air Basin (SCAB) by 2010. It will also provide a spill-over benefit to the rest of the state as cleaner locomotives designated for South Coast travel through other parts of the state. ARB staff estimated that the Agreement could provide the San Diego Air Basin with a spill-over benefit for NO_x and diesel PM emissions of about 15% by 2010.

Statewide Railroad Agreement (2005): ARB and both UP and BNSF signed a voluntary statewide agreement in 2005 which does not change any federal, state, or local authorities to regulate railroads. The Agreement has resulted in measures that have achieved a 20% reduction in locomotive diesel PM emissions in and around rail yards since its adoption in June 2005. The measures in the Agreement include:

- Phasing out of non-essential idling on all locomotives without idle reduction devices (60 minute limit – fully implemented);
- Installing idle reduction devices on 99% of the 450 California-based locomotives by June 30, 2008 (15 minute limit – 95% implemented);
- Identifying and expeditiously repairing locomotives with excessive smoke and ensure that at least 99% of the locomotives operating in California pass smoke inspections (fully implemented);

- Requiring all locomotives that fuel in the state use at least 80% federal or California ultra low sulfur (15 parts per million) diesel fuel by January 1, 2007 (six years prior to federal requirement – fully implemented);
- Preparing new health risk assessments for 16 major railyards, based on the UP Roseville Railyard Health Risk Assessment (completed in 2004) and OEHHA Guidelines (nine of 16 finalized in November 2007); and
- Identifying and implementing future feasible mitigation measures based on the results of the railyard health risk assessments.

ARB Diesel Fuel Regulations Extended to Intrastate Locomotives (2007): This regulation, approved in 2004, requires intrastate locomotives that operate 90% of the time in the state to use only California ultra low sulfur (15 parts per million) diesel fuel. CARB diesel's lower aromatics provide on average a 6% reduction in NO_x and 14% reduction in diesel PM emissions as compared to U.S. EPA ultra low sulfur on-road diesel fuel. The regulation took effect on January 1, 2007.

ARB Cargo Handling Equipment Regulations (2007): This regulation, approved in 2005, requires the control of emissions from more than 4,000 pieces of mobile cargo handling equipment, such as yard trucks and forklifts that operate at ports and intermodal rail yards. Implementation of this regulation will reduce diesel PM by approximately 40% in 2010 and 65% in 2015, and NO_x emissions by approximately 25% in 2010 and 50% in 2015. This regulation is expected to reduce diesel PM and NO_x emissions by up to 80% by 2020. The regulation took effect on January 1, 2007.

Heavy-Duty Diesel New Trucks Regulations: ARB and the U.S. EPA both have adopted emission standards for 2007 and subsequent model year heavy-duty diesel engines. These standards represent a 90% reduction of NO_x emissions, 72% reduction of non-methane hydrocarbon emissions, and a 90% reduction of PM emissions compared to the 2004 model year emission standards. The ARB adopted similar emission standards and test procedures to reduce emissions from 2007 and subsequent model year heavy-duty diesel engines and vehicles. These stringent emission standards will reduce NO_x and diesel PM emissions statewide from on-road heavy diesel trucks by approximately 50 and 3 tons per day, respectively, in 2010; by 140 and 6 tons per day, respectively, in 2015; and by 210 and 8 tons per day, respectively, in 2020.

ARB Statewide Diesel Truck and Bus Regulation: The ARB is developing a regulation to reduce diesel PM, NO_x, and greenhouse gas emissions from on-road heavy-duty diesel-fueled vehicles. This measure will cover long and short haul truck-tractors, construction related trucks, wholesale and retail goods transport trucks, tanker trucks, package and household goods transport trucks, and most other diesel-powered trucks and buses with a gross vehicle weight rating of 14,000 pounds or greater (shuttle buses of all sizes will also be included). The goals of this effort are: (a) by 2014, emissions are to be no higher than a 2007 model year engine with a diesel particulate filter, and (b) by 2021, emissions are to be no higher than a 2010 model year engine.

With the implementation of the proposed measure, California's emissions from this sector could be reduced by about 70%, and NO_x emissions by up to 35% in 2014. This measure is scheduled for ARB Board consideration in October 2008.

ARB Regulation to Control Emissions from In-Use On-Road Diesel-Fueled Heavy-Duty Drayage Trucks at Ports and Intermodal Railyard Facilities: The ARB developed a port truck fleet modernization program that will reduce diesel PM by 86% by 2010, and NO_x by 56% by 2014, as compared to the 2007 baseline. There are an estimated 20,000 drayage trucks operating at California's ports and intermodal railyards. These trucks are a significant source of air pollution, with about 3 tons per day of diesel PM and 61 tons per day of NO_x in 2007. Drayage trucks also often operate in close proximity to communities. This regulation will result in significant reductions in exposure and potential cancer risks to residents that live near ports, railyards, and the major roadways. The ARB approved the regulation in December 2007.

ARB Tier 4 Off-Road Diesel-Fueled New Engine Emission Standards: In 2004, the ARB and U.S. EPA adopted a fourth phase of emission standards (Tier 4). New off-road engines are now required to meet aftertreatment-based exhaust standards for particulate matter (PM) and NO_x starting in 2011. The Tier 4 standards will achieve over a 90% reduction over current levels by 2020, putting off-road engines on a virtual emission par with on-road heavy duty engines.

Transport Refrigeration Unit (TRU) Airborne Toxics Control Measure (ATCM): This airborne toxics control measure is applicable to refrigeration systems powered by integral internal combustion engines designed to control the environment of temperature sensitive products that are transported in trucks, trailers, railcars, and shipping containers. Transport refrigeration units may be capable of both cooling and heating. Estimates show that diesel PM emissions for transport refrigeration units and transport refrigeration unit gen-set engines will be reduced by approximately 65% in 2010 and 92% in 2020. California's air quality will also experience benefits from reduced NO_x emissions and reduced HC emissions. The transport refrigeration unit air toxics control measure is designed to use a phased approach over about 15 years to reduce the diesel PM emissions from in-use transport refrigeration unit and transport refrigeration unit generator set engines that operate in California. The TRU ATCM was approved on February 26, 2004 and became effective on December 10, 2004. Compliance dates for meeting in-use performance standards will be phased in, beginning December 31, 2008, and will extend out in time from there.

U.S. EPA Locomotive Emission Standards: Under the Federal Clean Air Act, U.S. EPA has sole authority to adopt and enforce locomotive emission standards. Under U.S. EPA's rules, this preemption also extends to the remanufacturing of existing locomotives. In April 2007, U.S. EPA released a proposed locomotive rulemaking that would reduce Tier 0 locomotive NO_x emissions by 20% and Tier 0-3 remanufacture and new standards to reduce PM by 50%. The ARB is relying on U.S. EPA to expeditiously require the introduction of the next generation, or Tier 4, locomotive emission standards that require Tier 4 locomotives built with diesel particulate filters and selective catalytic reduction. Combined, these exhaust aftertreatment devices are expected to provide up to a 90% reduction in NO_x and PM emissions beginning in 2015. The final U.S. EPA locomotive regulations were released on March 14, 2008.

ARB Goods Movement Emission Reduction Plan (GMERP): Approved in 2006, this plan forecasts goods movement emissions growth and impacts. It contains a comprehensive list of proposed strategies to reduce emissions from ships, trains, and trucks and to maintain and improve upon air quality. The strategies in the plan, if fully implemented, would reduce locomotive NO_x and diesel PM emissions by up to 85% by 2020.

California Yard Locomotive Replacement Program: One locomotive strategy being pursued is to replace California's older yard locomotives that operate in and around railyards statewide. Yard locomotives represent about 5% of the statewide locomotive NO_x and diesel PM emissions, but often occur in railyards located in densely populated urban centers. Multiple nonroad engine (gen-set) and electric-hybrid yard locomotives have demonstrated they can reduce NO_x and diesel PM emissions by up to 90% as compared to existing locomotives. As of 2008, UP has deployed 60 gen-set and 12 electric hybrid yard locomotives in southern California. BNSF has been operating four liquefied natural gas (LNG) yard locomotives in downtown Los Angeles since the mid-1990s. UP and BNSF have ordered more gen-set locomotives for use in northern California in 2008.

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III. BNSF SAN DIEGO RAILYARD DIESEL PM EMISSIONS

In this chapter, we provide a summary of the diesel particulate matter (PM) emissions inventory for the BNSF Railway's (BNSF) San Diego Railyard.

In 2005, the combined diesel PM emissions from the BNSF San Diego Railyard and significant off-site emission sources within a one-mile distance (off-site emissions) were estimated at about 13.3 tons per year. The off-site diesel PM emissions from mobile sources are estimated at approximately 6.0 tons per year, or about 45% of the total combined emissions. Off-site stationary sources contribute 5.6 tons per year of diesel PM emissions, or about 42% of the total combined emissions. The diesel PM emissions at the BNSF San Diego Railyard are estimated at about 1.7 tons per year, accounting for about 13% of the total combined diesel PM emissions.

A. On-Site BNSF San Diego Railyard Diesel PM Emissions Summary

The BNSF San Diego Railyard activity data and emission inventories were provided by the BNSF Railway and its consultant, ENVIRON International Corporation. The methodology used to calculate the diesel PM and other toxic air contaminant emissions is based on the ARB *Rail Yard Emissions Inventory Methodology* (ARB, 2006e). Detailed calculation methodologies and resulting emission factors are included in the ENVIRON Report (see ARB website http://www.arb.ca.gov/railyard/hra/hra.htm).

The facility operations at the BNSF San Diego Railyard are detailed in the ENVIRON Report, and summarized below.

The main purpose of the BNSF San Diego Railyard is to make up trains. Making up trains is the process of breaking up arriving trains into railcars (representing a collection of cars or a piece of a train) and compiling of railcars to complete trains for departure.

The railcars are moved within the railyard to form trains by switching locomotives. A total of four switchers operate at the BNSF San Diego Railyard. The switchers operate on both ends of the railyard and partially outside the yard's boundaries. The center of the railyard is used mainly for railcar parking. Ready trains will leave the yard north-eastward. Two trains are made-up at the BNSF San Diego Railyard per day. There is an additional train that passes through the yard each day with no change to the railcar configuration. Therefore, a total of three trains arrive in the BNSF San Diego Railyard per day, for a total of about 1,100 trains per year.

The movement of railcars and assembly of trains is the only significant activity at the BNSF San Diego Railyard. No cargo handling operation occurs within the railyard. The railcars are loaded and unloaded elsewhere. Prior to 2005, the BNSF San Diego Railyard included a loading facility for autos. The auto loading activity, which occupied half of the yard area, is no longer in service. The tracks and facilities are leased to third parties.

The main rail line for through traffic runs northeast of East Harbor Drive, and is separated from the BNSF San Diego Railyard. Therefore, traffic on those tracks will not be included in the railyard's inventory.

The make-up of trains and their departure, as well as the passing of complete trains, are the most significant locomotive activities at the BNSF San Diego Railyard. The engine-on locomotive operations include switching activities, arriving and departing trains, as well as their maneuvering activities in the classification yard. There are no passing train activities. Service activities are limited to a small amount of locomotive refueling. About every four days, a switcher engine is refueled at one of the two direct to locomotive (DTL) or truck to locomotive fueling sites. There are no locomotive inspections at the BNSF San Diego Railyard.

Locomotive arriving and departing activities take place throughout the railyard. To characterize diesel PM emissions from the other on-site sources, they are allocated into different areas based on specific activities. Locomotive switching and train make-up activities are shown in Figure III-1, and locomotive refueling activities are shown in Figure III-2. The detailed schematic and descriptions of the areas and activities are also presented in the ENVIRON Report.

Figure III-1: Locomotive Switching and Train Make-Up Activity at the BNSF San Diego Railyard

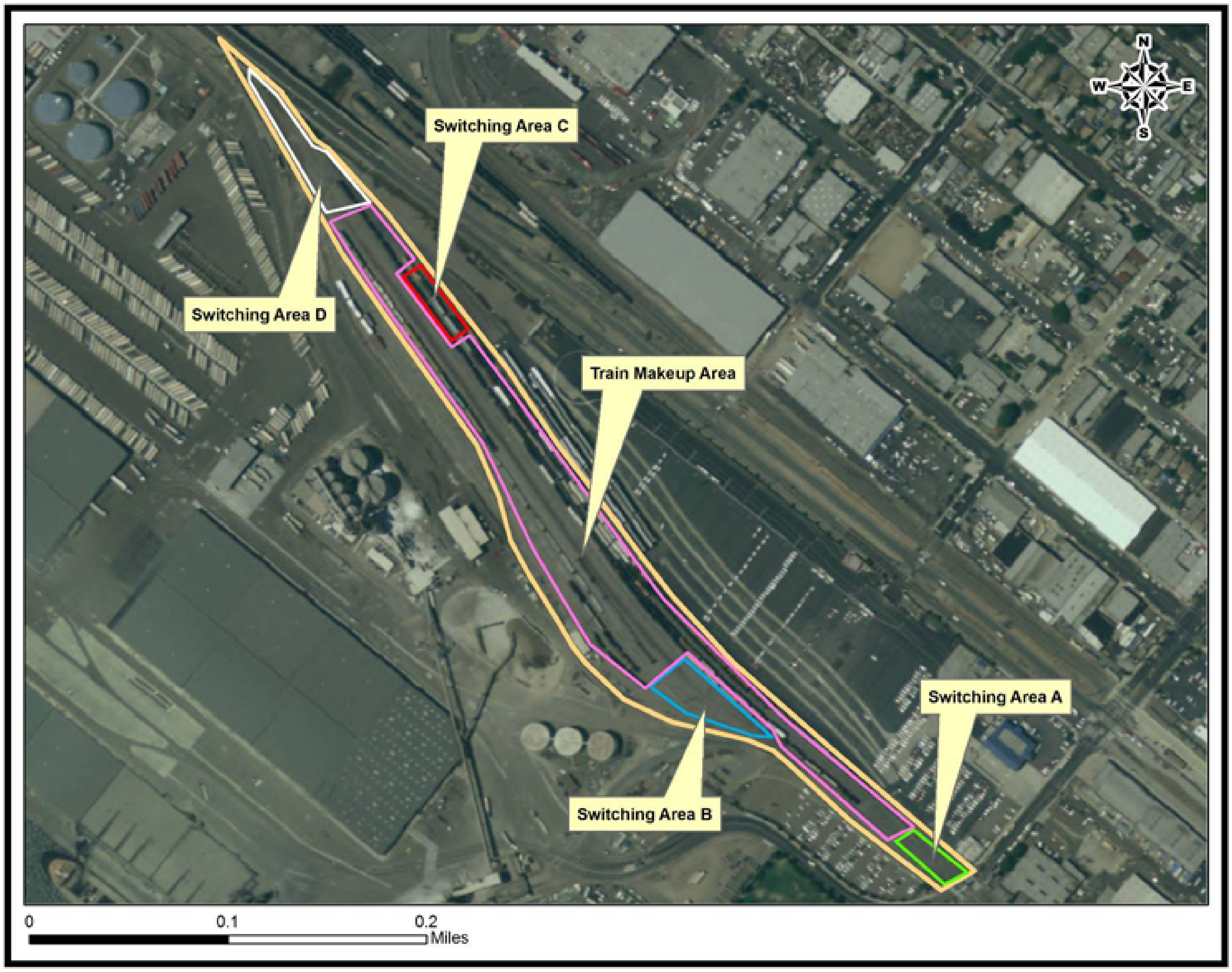
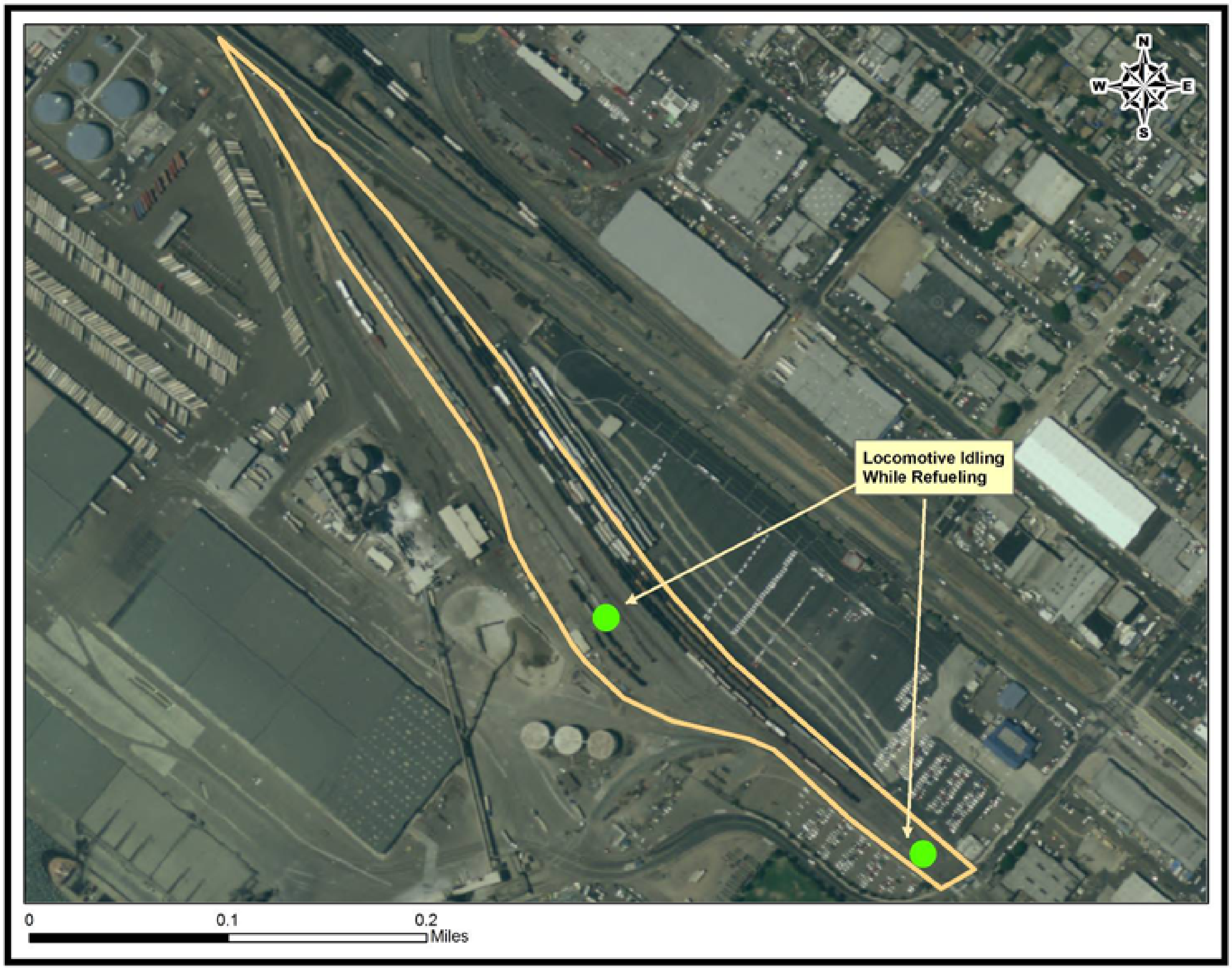


Figure III-2: Locomotive Refueling at the BNSF San Diego Railyard



With the data provided by BNSF and the methodology described in the ENVIRON Report, the diesel PM emissions for the BNSF San Diego Railyard were calculated at about 1.67 tons per year for the year 2005. The total diesel PM emission inventory within the railyard is summarized in Table III-1 by different source categories. As shown in Table III-1, emissions from locomotives comprise about 98% of the total emissions, at 1.63 tons per year. The remaining 2% is composed of off-road equipment and transport refrigeration units (TRUs), both at 0.02 tons per year (1% of the total each).

Table III-1: Summary of Diesel PM Emissions at the BNSF San Diego Railyard

On-Site Source Types	Tons Per Year	Percentage
Locomotive	1.63	98%
Off-Road Equipment	0.02	1%
Transport Refrigeration Units (TRUs)	0.02	1%
Total	**1.67**	**100%**

1. Locomotive Emissions

Locomotives are by far the largest diesel PM emission source at the BNSF San Diego Railyard. Locomotives contribute about 1.63 tons per year, or about 98% of the total railyard diesel PM emissions.

As shown in Table III-2, the highest percentage of locomotive diesel PM emissions result from locomotive arrivals and departures, accounting for about 90% of the total locomotive diesel PM emissions (1.47 tons per year): 1.37 tons per year from line haul locomotives, and 0.10 tons per year from switchers performing short-haul operations. Switching operations generate about 10% of the total locomotive diesel PM emissions, at 0.16 tons per year. Refueling generates a very small amount of diesel PM emissions, at only 0.005 tons per year.

Temporal emission profiles are estimated for each activity based on hourly locomotive counts. The profiles developed account for hourly (diurnal) and seasonal temporal variations and are reflected in the air dispersion modeling to capture operational variations.

The locomotive diesel PM emission factors used in this study are presented in Appendix D.

Table III-2: Diesel PM Emissions by Locomotive Operation Activities

Operation Activity	Tons per Year[‡]	Percentage[‡]
Arrivals and Departures	1.47	90%
Switchers	*0.10*	*6%*
Line Haul	*1.37*	*84%*
Switching	0.16	10 %
Refueling	0.005	<1%
Total	**1.63**	**100 %**

‡ Numbers may not add precisely due to rounding.

The ARB has developed an integrated approach to reduce statewide locomotive emissions through a combination of voluntary agreements, ARB and U.S. EPA regulations, incentive funding programs, and early replacement of California's line haul and yard locomotive fleets. The detailed approach is discussed in Chapter II. In the future, the BNSF San Diego Railyard will benefit from these mitigation measures as diesel PM emissions from locomotives are gradually reduced as the locomotive fleets turn over.

2. Off-Road Equipment

The off-road equipment consists of BNSF California track maintenance equipment, such as forklifts, air compressors, rubber-tired cranes, and backhoes. The track maintenance equipment is not specifically assigned to the BNSF San Diego Railyard, but is used to service tracks anywhere in California in order to maintain the network.

The approach used in the ENVIRON Report to determine the track maintenance equipment diesel PM emissions for the BNSF San Diego Railyard was first to calculate the diesel PM emissions for all California track maintenance equipment, and then to proportionate for the BNSF San Diego Railyard based on track mileage.

Diesel PM emissions were calculated using the latest version of the ARB OFFROAD model. This showed that total diesel PM emissions were an estimated 5.0 tons per year for all of the BNSF California track maintenance equipment.

The relative track mileage (including tracks, main line, and other tracks) for the BNSF San Diego Railyard was then compared to the total California track mileage: the BNSF San Diego Railyard has 12 miles of track within its boundaries, 0.32% of the California regional total of 3,779 miles. The estimated total diesel PM emissions of 5.0 tons per year for all BNSF California track maintenance equipment was then multiplied by 0.32%, to give 0.02 tons per year of diesel PM emissions for track maintenance equipment at the BNSF San Diego Railyard.

3. Transport Refrigeration Units

Transport refrigeration units (TRUs) are used to regulate temperatures during the transport of products with controlled temperature requirements. In BNSF operations, temperatures are regulated by TRUs in shipping containers and in railcars when the material that is being shipped requires such temperature regulation.

Emissions from TRUs were estimated in accordance with the methodology presented in ARB EMFAC-2005 and the draft OFFROAD model. In the ENVIRON Report, TRU yearly activity was estimated using the time onsite by TRU configuration (either railcar or shipping container) and mode of transportation provided by BNSF. The activity data were then used in the OFFROAD model to estimate the TRU emissions. An additional factor of 0.6 was by used by ENVIRON to account for the only temporary use of TRU units.

For the year 2005, a total of 97 railyard visits by operating TRUs were recorded, with diesel PM emissions of 0.02 tons per year (ENVIRON Report).

The TRU airborne toxics control measure (ATCM) is designed to use a phased approach over about 15 years to reduce the diesel PM emissions from in-use TRUs and TRU generator set (gen-set) engines that operate in California. Compliance dates for meeting in-use performance standards will be phased in, beginning December 31, 2008, and will extend out in time from there. Estimates show that the TRU ATCM will reduce diesel PM emissions for TRUs and TRU gen-set engines by approximately 65% in 2010 and 92% in 2020.

4. Other Sources

The only regular truck trips to the BNSF San Diego Railyard are fueling trucks. Approximately every fourth day, a fueling truck enters the site to provide fuel for a locomotive. There were approximately 92 refueling events in 2005.

The fueling trucks enter the yard south-east from Cesar E. Chavez Parkway. The routes followed by the refueling trucks are shown in Figure III-2. The travel distances to the two DTL stations are 0.09 miles and 0.5 miles round trip. Fueling takes about 30 minutes, with a total of 60 minutes idling assumed per one fueling activity.

The total diesel PM emissions for the fueling trucks were estimated at 0.8 pounds for the year 2005. The fueling truck emissions are, therefore, de minimis, and will not be included in this inventory nor in the air dispersion modeling analysis.

5. Other Toxic Air Contaminant Emissions

The on-road fleet at BNSF San Diego Railyard consists of three gasoline-powered vehicles. Some of the track maintenance equipment at the railyard runs on liquefied petroleum gas (LPG) and compressed natural gas (CNG). As a result, diesel PM is not the only toxic air contaminant emitted at BNSF San Diego Railyard. The total organic gases from gasoline, LPG, and CNG operations in the railyard are estimated at about 0.01 tons per year, or 30 pounds per year, compared to 1.67 tons per year of diesel emissions in the railyard.

The total organic gases are speciated according to ARB Speciate Profile #2105 for exhaust emissions and ARB Speciate Profile #422 for evaporative emissions. Most of the toxic air contaminants in the total organic gases are not identified as carcinogen according to the OEHHA Guidelines (OEHHA, 2003). When the exhaust and evaporative emissions profiles are combined, benzene, formaldehyde, and 1,3-butadiene are the only toxic air contaminants among the top five cancer contributors, and total about 0.7 pounds per year. Calculation of potency weighted emissions for the on-site toxic air contaminants (see a similar analysis for off-site contaminants in Table III-6) shows a substantially lower level of potential cancer risk, about a factor of 38,000 less than the cancer risk level for diesel PM. Hence, only diesel PM emissions are presented in the on-site emission analysis.

B. Off-Site Emission Inventory

ARB staff analyzed the significant off-site emission sources based on two categories: mobile and stationary. The off-site diesel PM emissions for the sources within a one-mile distance from the boundary of the BNSF San Diego Railyard are divided about evenly between mobile sources, at about 6.0 tons per year; and stationary sources, at about 5.6 tons per year. The off-site mobile and stationary diesel PM emissions total 11.6 tons per year, or about 87% of the combined on-site and off-site diesel PM emissions.

1. Mobile Sources

For the off-site mobile sources, the analysis focused on on-road heavy duty diesel trucks, as they are the primary source of diesel PM from the on-road vehicle fleet. ARB staff estimated mobile emissions based on roadway specific vehicle activity data and allocated them to individual **roadway links**. All roadway links within a one-mile distance from the BNSF San Diego Railyard are included in the analysis. The estimates do not include the diesel PM emissions generated by idling of heavy-duty trucks. Off-road equipment is not included in the analysis. Individual sources such as local truck distribution centers and warehouses were not evaluated due to insufficient activity data, but their truck traffic related to these facilities is reflected in the roadway link traffic activities.

> **Roadway link:** is defined as a discrete section of roadway with unique estimates for the fleet specific population and average speed and is classified as a freeway, ramp, major arterial, minor arterial, collector, or centroid connector.

The off-site diesel PM mobile source emissions were estimated based on traffic flow. As shown in Table III-3, about 2.4 tons per year of the off-site mobile diesel PM emissions, about 40% of the total, is from diesel-fueled trucks traveling on the two major freeways within one mile of the railyard: I-5 and SR-75. The remaining 3.5 tons per year of off-site diesel PM emissions, nearly 60% of the total, is from diesel-fueled trucks traveling on local streets.

The diesel PM off-site source emissions are also calculated by different classifications of truck gross vehicle weights, as shown in Table III-4. For the year 2005, the total diesel PM emissions are divided about evenly among light heavy-duty, medium heavy-duty and heavy heavy-duty trucks. The methodology for mobile diesel PM emission estimation is presented in Appendix A.

Table III-3: Off-Site Mobile Source Diesel PM Emissions From Major Roadways Near the BNSF San Diego Railyard

Sources	Diesel PM Emissions	
	Tons Per Year*	Percent of Total*
I-5	1.6	27%
SR-75	0.8	13%
Local Streets	3.5	58%
Total	**6.0**	**100%**

*Numbers and percentages do not add precisely due to rounding

Table III-4: Off-Site Mobile Source Diesel PM Emissions by Vehicle Type Near the BNSF San Diego Railyard

Vehicle Types of Off-Site Mobile Diesel PM Sources	Gross Vehicle Weight (pounds)	Tons per year	Percent of Total*
Light Heavy-Duty Trucks	8,501-14,000	1.7	28%
Medium Heavy-Duty Trucks	14,001-33,000	2.0	33%
Heavy Heavy-Duty Trucks	> 33,000	2.3	39%
Total		**6.0**	**100%**

2. Stationary Sources

Emissions from off-site stationary source facilities are identified using the California Emission Inventory Development and Reporting System (CEIDARS) database, which contains information reported by the local air districts for stationary sources within their jurisdiction. The CEIDARS facilities whose locations fell within a one-mile distance of BNSF San Diego Railyard are selected. Diesel PM emissions are estimated from stationary internal combustion engines burning diesel fuel, operating at stationary sources reported in CEIDARS.

The CEIDARS facilities whose locations fell within a one-mile distance of the BNSF San Diego Railyard are selected. As can be seen in Table III-5, more than 99% of the off-site stationary diesel PM emissions are from two sources: National Steel and Shipbuilding, at 4.1 tons per year; and Southwest Marine Inc., at 1.5 tons per year.

Table III-5: Off-Site Stationary Source Diesel PM Emissions Near the BNSF San Diego Railyard

Source	Tons Per Year*	Percent of Total*
National Steel and Shipbuilding	4.1	73%
Southwest Marine, Inc.	1.5	27%
Continental Maritime of San Diego, Inc.	0.02	<1%
Total	**5.6**	**100%**

* Numbers and percentages do not add precisely due to rounding

The San Diego & Imperial Valley (SDIV) Railyard is located immediately to the northwest of the BNSF San Diego Railyard, across Harbor Drive. Three switchers operate at the SDIV Railyard, with total emissions estimated at 0.5 tons per year (SD Freight Consulting, 2005).

The San Diego Coast Express Rail, or Coaster, began operation in 1995. Coaster is a regional rail service, now administered by the San Diego Northern Railway, a subsidiary of the North County Transit District (NCTD).

The NCTD maintains two railyards, one of which is located north of Oceanside (approximately 50 miles north of the BNSF San Diego Railyard) and the other of which is shared with the San Diego Trolley at 12th Avenue and Imperial in San Diego (less than a mile northeast of the BNSF San Diego Railyard) (http://en.wikipedia.org/wiki/San_Diego_Coaster). Based on the 2003 *CARB Diesel Fuel Survey*, ARB estimates that Coaster diesel PM emissions within the NCTD railyard in San Diego total about 0.6 tons per year.

The SDIV Railyard and the NCTD railyard in San Diego were not included in the off-site emissions and air dispersion analysis because they were not subject to the 2005 ARB/Railroad Agreement. However, their emissions were estimated in order to recognize their potential emission impacts and proximity to the BNSF San Diego Railyard.

3. Non-Diesel PM Toxic Air Contaminants

ARB staff also evaluated other toxic air contaminant emissions around the BNSF San Diego Railyard. Within a one-mile distance of the railyard, 32 stationary toxic air contaminant sources were identified. For the year 2005, the total emissions of toxic air contaminants other than diesel PM emitted from stationary sources within a one-mile distance from the railyard are estimated at about 213 tons per year. Over 60 toxic air contaminants are identified among these emissions, in which isopropyl alcohol, n-butyl alcohol, and xylenes are three major contributors with emissions estimated at 74, 63, and 14 tons per year, respectively.

Not all of these toxic air contaminants are identified as carcinogens. According to ARB's *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (ARB, 2000), diesel PM, 1,3-butadiene, benzene, carbon tetrachloride, and formaldehyde are defined as the top five cancer risk contributors, based on ambient concentrations. These toxic air contaminants account for 95% of the State's estimated potential cancer risk levels. This study also concluded that diesel PM contributes over 70% of the State's estimated potential cancer risk levels, significantly higher than other toxic air contaminants (ARB, 2000). At the BNSF San Diego Railyard, the top five cancer risk contributors (other than diesel PM) are estimated at about 1.3 tons per year.

The Office of Environmental Health Hazard Assessment (OEHHA) has estimated an inhalation **cancer potency factor** for individual chemicals and some chemical mixtures such as whole diesel exhaust. Diesel PM contains many individual cancer-causing chemicals. The individual cancer-causing chemicals are not separately evaluated so as to avoid double counting. The four compounds listed here are given a weighting factor by comparing each compound's cancer potency factor to the diesel PM cancer potency factor. This factor is multiplied by the estimated emissions for that compound, which gives the potency weighted estimated toxic emissions as shown in Table III-12. As can be seen, the potency weighted toxic emissions for these toxic air contaminants are de minimis, at about 0.04 tons per year. Hence, they are not included in the analysis.

> **Cancer potency factors** are expressed as the 95% upper confidence limit of excess cancer cases occurring in an exposed population assuming continuous lifetime exposure to a substance at a dose of one milligram per kilogram of body weight, and are expressed in units of $(mg/kg\text{-}day)^{-1}$.

Table III-6: Potency Weighted Estimated Toxic Emissions from Significant Off-Site Stationary Sources Surrounding BNSF San Diego Railyard

Toxic Air Contaminant	Cancer Potency Factor	Weighting Factor	Actual Emission (Tons Per Year)	Potency Weighted Toxic Emission (Tons Per Year)
Diesel PM	1.1	1	11.6	11.6
1,3-Butadiene	0.6	0.55	0.001	0.0005
Benzene	0.1	0.09	0.24	0.02
Carbon Tetrachloride	0.15	0.14	0	0
Formaldehyde	0.021	0.02	1.03	0.02
Total (other than diesel PM)			**1.3**	**0.04**

The detailed methodology of off-site stationary source emissions is presented in Appendix B.

In addition, ARB staff evaluated the potential cancer risk levels contributed by the use of gasoline in the San Diego Air Basin. Table III-7 shows the emissions of four primary carcinogen compounds from gasoline exhausts in the San Diego Air Basin in 2005 (ARB, 2006c). As indicated in Table III-7, the cancer potency weighted emissions of these four toxic air contaminants from all types of gasoline sources are estimated at about 209 tons per year, or about 12% of diesel PM emissions in the San Diego Air Basin. If only gasoline-powered vehicles are considered, the potency weighted emissions of these four TACs are estimated at about 100 tons per year, or equivalent to about 6% of diesel PM emissions in the San Diego Air Basin. Hence, gasoline-powered vehicular sources are not included in the analysis.

Table III-7: Emissions of Major Toxic Air Contaminants From Use of Gasoline in the San Diego Air Basin

Compound	Toxic Air Contaminant Emissions (Tons Per Year)			
	From All Sources	Potency Weighted*	From Gasoline Vehicles	Potency Weighted*
Diesel PM	1,800	**1,800**	-	-
1,3-Butadiene	190	**104**	97	**53**
Benzene	849	**76**	460	**41**
Formaldehyde	1,240	**25**	250	**5**
Acetaldehyde	497	**4**	72	**0.6**
Total (other than diesel PM)	2,776	**209**	879	**100**

* Based on cancer potency weighting factors.

C. Current Available Diesel Fuel Regulations and Their Benefits to the Railyards

1. California Air Resources Board (CARB) Diesel Fuel Specifications

The original California diesel fuel specifications were approved by the Board in 1988 and limited sulfur and aromatic contents. The requirements for "CARB diesel," which became applicable in October 1993, consisted of two basic elements:

- A limit of 500 parts per million by weight (ppmw) on sulfur content to reduce emissions of both sulfur dioxide and directly emitted PM.
- A limit on aromatic hydrocarbon content of 10% by volume for large refiners and 20% for small refiners to reduce emissions of both PM and NO_x.

At a July 2003 hearing, the Board approved changes to the California diesel fuel regulations that, among other things, lowered the maximum allowable sulfur levels in California diesel fuel to 15 ppmw beginning in June 2006. ARB's specifications for sulfur and aromatic hydrocarbons are shown in Table III-8.

Table III-8: California Diesel Fuel Standards

Implementation Date	Maximum Sulfur Level (ppmw)	Aromatics Level (% by volume)	Cetane Index
1993	500	10	N/A
2006	15	10	N/A

The regulation limiting aromatic hydrocarbons also includes a provision that enables producers and importers to comply with the regulation by qualifying a set of alternative specifications of their own choosing. The alternative formulation must be shown, through emissions testing, to provide emission benefits equivalent to that obtained with a 10% percent aromatic standard (or in the case of small refiners, the 20% standard). Most refiners have taken advantage of the regulation's flexibility to produce alternative diesel formulations that provide the required emission reduction.

2. U.S. EPA On-Road Diesel Fuel Specifications

The United States Environmental Protection Agency (U.S. EPA) has also established separate diesel fuel specifications for on-road diesel fuel and off-road (non-road) diesel fuel. The former U.S. EPA diesel fuel standards were applicable in October 1993. The U.S. EPA regulations prohibited the sale or supply of diesel fuel for use in on-road motor vehicles, unless the diesel fuel had a sulfur content no greater than 500 ppmw. In addition, the regulation required on-road motor-vehicle diesel fuel to have a cetane index of at least 40 or have an aromatic hydrocarbon content of no greater than 35% by volume (vol. %). All on-road motor-vehicle diesel fuel sold or supplied in the United States, except in Alaska, must comply with these requirements. Diesel fuel, not intended for on-road motor-vehicle use, must contain dye Solvent Red 164.

On January 18, 2001, the U.S. EPA published a final rule which specified that, beginning June 1, 2006, refiners must begin producing highway diesel fuel that meets a maximum sulfur standard of 15 ppmw for all and later model year diesel-fueled on-road vehicles. The current U.S. EPA on-road diesel fuel standard is shown in Table III-9.

3. U.S. EPA Non-Road Diesel Fuel Specifications

Until recently, fuel supplied to outside of California was allowed a sulfur content of up to 5,000 ppmw. However, in 2004, the U.S. EPA published a strengthened rule for the control of emissions from non-road diesel engines and fuel. The U.S. EPA rulemaking requires that sulfur levels for non-road diesel fuel be reduced from current uncontrolled levels of 5,000 ppmw ultimately to 15 ppmw. An interim cap of 500 ppmw is contained in the rule: beginning June 1, 2007, refiners were required to produce non-road, locomotive, and marine diesel fuel that meets a maximum sulfur level of 500 ppmw. This does not include diesel fuel for stationary sources. In 2010, non-road diesel fuel will be required to meet the 15 ppmw standard except for locomotives and marine vessels. In 2012, non-road diesel fuel used in locomotives and marine applications must meet the 15 ppmw standard. The non-road diesel fuel standards are shown in Table III-9.

Table III-9: U.S. EPA Diesel Fuel Standards

Applicability	Implementation Date	Maximum Sulfur Level (ppmw)	Aromatics Maximum (% by volume)	Cetane Index‡ (Minimum)
On-Road	2006	15	35	40
Non-road*	1993	5,000	35	40
Non-road*	2007	500	35	40
Non-road, excluding loco/marine*	2010	15	35	40
Non-road, loco/marine*	2012	15	35	40

* Non-road diesel fuels must comply with ASTM No. 2 diesel fuel specifications for aromatics and cetane index.

‡ A measure of the combustion quality of diesel fuel via the compression ignition process.

4. What Are the Current Properties of In-Use Diesel Fuel?

Table III-10 shows average values for in-use levels of sulfur and four other properties for motor vehicle diesel fuel sold in California after the California and Federal diesel fuel regulations became effective in 1993. The corresponding national averages are shown for the same properties for on-road diesel fuel only, since the U.S. EPA sulfur standard does not apply to off-road or non-vehicular diesel fuel. Non-road diesel fuel sulfur levels have been recorded as about 3,000 ppmw in-use, and aromatics have been recorded at about 35% by volume in-use.

Table III-10: Average 1999 Properties of Reformulated Diesel Fuel

Property	California	U.S.[(1)]
Sulfur, ppmw	10[(2)]	10[(2)]
Aromatics, vol.%	19	35
Cetane No.	50	45
Polynuclear Aromatics, wt.%	3	NA
Nitrogen, ppmw	150	110

(1) U.S. EPA, December 2000.
(2) Based on margin to comply with 15 ppmw sulfur standards in June 2006.

5. Diesel Fuels Used by California-Based Locomotives

The ARB Board approved a regulation in November 2004, which extended the CARB diesel fuel requirements to intrastate locomotives (those operating 90% or more of the time in California) effective on January 1, 2007. UP and BNSF agreed in the 2005 railroad Agreement to dispense only CARB diesel or U.S. EPA on-road diesel fuels to a minimum of 80% of interstate locomotives that fuel in California beginning on January 1, 2007.

Line haul locomotives have a range of about 800 to 1,200 miles between fuelings. BNSF locomotives typically refuel at Belen, New Mexico before traveling to Barstow, California; UP locomotives typically fuel at Rawlins, Wyoming or Salt Lake City, Utah before traveling to Roseville in northern California or Colton in southern California. These major out-of-state railroad facilities have the option to use Federal non-road diesel fuels for the refueling of line haul locomotives. When these out-of-state line haul locomotives arrive in California, they typically have about 10% remaining volume of diesel fuel relative to their tank capacity.

UP and BNSF surveyed each of the California fueling centers, and major interstate fueling centers to California, to estimate the average diesel fuel properties for locomotives for the railyard health risk assessments. Diesel fuel sulfur levels were estimated to be an average of 1,100 ppmw based on the mixture of CARB, U.S. EPA on-road, and non-road diesel fuel consumed by locomotives in California in 2005: this was the sulfur level used to calculate diesel PM emissions. ARB staff believes this is a conservative estimate for the types of diesel fuels and sulfur levels consumed by locomotives in California.

The U.S. EPA on-road and CARB on- and off-road diesel ultra low sulfur specifications (15 ppmw) went into effect on June 1, 2006. The CARB diesel fuel requirements for intrastate locomotives went into effect on January 1, 2007. The U.S. EPA non-road diesel fuel sulfur limit will drop from 5,000 ppmw to 500 ppmw on June 1, 2007. In 2012, the non-road diesel fuel limits for used in locomotives and marines will drop from 500 ppmw to 15 ppmw.

The NO_x emission benefits associated with the use of CARB diesel compared to U.S. EPA on-road and non-road diesel fuels are due to the CARB aromatic hydrocarbon limit of 10% by volume or an emission equivalent alternative formulation limit. ARB staff estimates that use of CARB diesel provides a 6% reduction in NO_x and a 14% reduction in particulate matter emissions compared with the use of U.S. EPA on-road and non-road diesel fuels. In addition, CARB diesel fuel will provide over a 95% reduction in fuel sulfur levels in 2007 compared to U.S. EPA non-road diesel fuel. This reduction in diesel fuel sulfur levels will provide oxides of sulfur (SO_x) emission reductions, and additional PM emission reductions by reducing indirect (secondary formation) PM emissions formed from SO_x.

In addition, the ARB, UP and BNSF entered into an agreement in 2005, which included a provision requiring that at least 80% of the interstate locomotives be fueled with either CARB diesel or U.S. EPA on-road ultra low sulfur diesel fuel by January 1, 2007. Both the CARB diesel fuel regulation for intrastate locomotives and the 2005 Railroad Agreement for interstate locomotives require the use of ultra low sulfur diesel fuel in 2007, five years earlier than the U.S. EPA non-road diesel fuel regulations for locomotives in 2012.

6. What Are the Potential Overall Benefits from the Use of Lower Sulfur Diesel Fuels?

Both the U.S. EPA and CARB diesel fuels had sulfur levels lowered from 500 ppmw to 15 ppmw on June 1, 2006. Under the prior sulfur specification of 500 ppmw, CARB diesel fuel in-use sulfur levels averaged around 140 ppmw versus U.S. EPA on-road sulfur levels of about 350 ppmw. With the 2006 implementation of the 15 ppmw sulfur levels, in-use levels for both CARB diesel and U.S. EPA on-road now average about 10 ppmw.

Sulfur oxides and particulate sulfate are emitted in direct proportion to the sulfur content of diesel fuel. Reducing the sulfur content of diesel fuel from the California's statewide average of 140 ppmw to less than 10 ppmw would reduce sulfur oxide emissions by about 90% or by about 6.4 tons per day from 2000 levels. Direct diesel PM emissions would be reduced by about 4%, or about 0.6 tons per year in 2010 for engines not equipped with advanced particulate emissions control technologies. U.S. EPA on-road lower sulfur diesel fuel would provide similar levels of sulfur oxide and direct diesel PM emission reductions.

The emissions reductions would be obtained with low sulfur diesel used in mobile on-road and off-road engines, portable engines, and those stationary engines required by district regulations to use CARB diesel. In addition, NO_x emissions would be reduced by 7%, or about 80 tons per year for those engines not currently using CARB diesel, assumed to be about 10% of the stationary engine inventory and including off-road mobile sources such as interstate locomotives.

The lower sulfur diesel makes much more significant emissions reductions possible by enabling the effective use of advanced emission control technologies on new and retrofitted diesel engines. With these new technologies, emissions of diesel PM and NO_x can be reduced by up to 90%. Significant reductions of non-methane hydrocarbons and carbon monoxide can also be achieved with these control devices.

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IV. AIR DISPERSION MODELING OF BNSF SAN DIEGO RAILYARD

In this chapter, ARB staff presents the air dispersion modeling performed to estimate the transport and dispersion of diesel PM emissions resulting from the sources in and around the BNSF Railway's (BNSF) San Diego Railyard. A description of the air quality modeling parameters is listed, including air dispersion model selection, emission source characterizations, meteorological data, model receptor network, and building wake effects. ARB staff also describes model input preparation and output presentation.

A. Air Dispersion Model Selection

Air dispersion models are often used to simulate atmospheric processes for applications where the spatial scale is in the tens of meters to the tens of kilometers. Selection of air dispersion models depends on many factors, such as characteristics of emission sources (point, area, volume, or line), the type of terrain (flat or complex) at the emission source locations, and source-receptor relationships. For the BNSF San Diego Railyard, ARB staff selected the U.S. EPA's newly approved air dispersion model AERMOD to estimate the impacts associated with diesel PM emissions in and around the railyard. AERMOD stands for American Meteorological Society / Environmental Protection Agency Regulatory Model Improvement Committee (**AER**MIC) **MOD**EL. It is a state-of-science air dispersion model and is a replacement for its predecessor, the U.S. EPA Industrial Source Complex air dispersion model.

AERMOD has become a U.S. EPA regulatory dispersion model specified by the *U.S. EPA Guideline for Air Quality Methods (*40 CFR Part 51, Appendix W) (U.S. EPA, 2005). AERMOD is also the recommended model in the *ARB Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006b).

AERMOD is a steady-state plume model that incorporates current concepts about air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain. These approaches have been designed to be physically realistic and relatively simple to implement.

B. Source Characterization and Parameters

The emission sources from the locomotives and other diesel PM sources at the BNSF San Diego Railyard are characterized by source types, as required by the ARB Guidelines (ARB, 2006b). Emission sources were treated as either point, volume, or area sources in the dispersion modeling. Point source treatment includes calculated plume rise based on source stack dimensions and exhaust parameters, and hour-by-hour meteorological conditions; volume source treatment includes user-specified release height and initial horizontal and vertical dispersion; area source treatment includes user-specified initial vertical dimension and release height. Larger stationary emission sources (e.g., idling locomotives and cranes where present) were treated as a series of point sources within their areas of operation. Spacing between sources was selected based on the magnitude of emissions and the proximity to off-site receptors. Smaller and moving sources (e.g., idling and moving trucks, and moving locomotives) were treated as a series of volume sources. Source spacing and initial dispersion coefficients for volume sources were also selected based on the magnitude of the emissions and the proximity to off-site receptors.

The emission rates for individual locomotives are a function of locomotive makes, notch setting, activity time, duration, and operating location. Emission source parameters for locomotive model classifications at the railyard include emission source height, diameter, exhaust temperature, and exhaust velocity. Detailed information on the emission source parameters is presented in the ENVIRON Report. BNSF assumed more specific temperatures and stack heights from their switchers and line haul locomotives fleets. UP used data from the *Roseville Railyard Study* (ARB, 2004a), based on the most prevalent locomotive model of switchers and line hauls, to parameterize locomotive emission settings. In total, the UP and BNSF assumptions on the locomotive emission parameters are slightly different; however, both are within reasonable ranges according to their activities. The slight differences in stack height have an insignificant impact on predicted air concentrations, within 2%, based on a sensitivity analysis conducted by ARB staff.

For the stationary locomotives, the locations of individual locomotive emission sources used for the model inputs were determined based on the detailed locomotive distribution and activity information provided by BNSF. The emissions from all other stationary sources are simulated as a series of point sources.

C. Meteorological Data

In order to run AERMOD, the following hourly surface meteorological data are required: wind speed, wind direction, ambient temperature, and opaque cloud cover. In addition, the daily upper air sounding data need to be provided (U.S. EPA, 2004b).

These meteorological variables are important to describe the air dispersion in the atmosphere. The wind speed determines how rapidly the pollutant emissions are diluted and influences the rise of emission plume in the air, thus affecting downwind concentrations of pollutants. Wind direction determines where pollutants will be transported. The difference of ambient temperature and the emission releasing temperature from sources determines the initial buoyancy of emissions. In general, the greater the temperature difference, the higher the plume rise. The opaque cloud cover and upper air sounding data are used in calculations to determine other important dispersion parameters. These include atmospheric stability (a measure of turbulence and the rate at which pollutants disperse laterally and vertically) and mixing height (the vertical depth of the atmosphere within which dispersion occurs). The greater the mixing height is, the larger the volume of atmosphere is available to dilute the pollutant concentration.

The meteorological data used in the model are selected on the basis of representativeness. Representativeness is determined primarily on whether the wind speed/direction distributions and atmospheric stability estimates generated through the use of a particular meteorological station (or set of stations) are expected to mimic those actually occurring at a location where such data are not available. Typically, the key factors for determining representativeness are proximity of the meteorological station and the presence or absence of nearby terrain features that might alter airflow patterns.

For the area within 20 kilometers of the BNSF San Diego Railyard, nearly 40% is open water (i.e, the San Diego Harbor and the Pacific Ocean). Another 32% of the area is medium-intensity or high-intensity developed (ENVIRON Report). Out to about 10 kilometers, the land is generally flat, but between 10 kilometers and 20 kilometers there are hills to the northeast, east, and southeast. Therefore, the dominant terrain features and water bodies that could influence wind patterns in this area include the hills to the northeast, east, and southeast; and the Pacific Ocean and San Diego Harbor to the west and southwest.

The BNSF San Diego Railyard does not monitor meteorological variables on site. Wind speed, wind direction, and temperature data from the ARB-operated San Diego-Beardsley Station for the year 2006 as the most representative available wind speed, wind direction, and temperature data for use in the air dispersion analysis of the BNSF San Diego Railyard. Cloud cover and pressure data from the National Weather Service's San Diego Lindbergh Field for 2006 were used, since the ARB's San Diego-Beardsley Station did not collect pressure measurements in 2006 (ENVIRON, 2008b).

AERMET, the meteorological preprocessor for AERMOD, required (at a minimum) data from one surface National Weather Service (NWS) station and one upper air NWS station. ARB's San Diego-Beardsley Station was used for surface data, and the Miramar Naval Air Station in San Diego was used for upper air data (ENVIRON, 2008b).

According to ARB railyard health risk assessment guidelines (ARB, 2006b), five years of meteorological data are recommended to be used in the air toxic health risk assessment. Surface parameters supplied to the model were specified for the area surrounding the surface meteorological monitoring site as recommended by AERMOD and the ARB *Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006b). The meteorological data from 2006 were selected for the railyard dispersion modeling because the wind speed, wind direction, and temperature data were the most representative available (ENVIRON, 2008b). A detailed description of

meteorological data selection is discussed in *Air Dispersion Modeling Assessment of Air Toxic Emissions from BNSF San Diego Railyard* (ENVIRON, 2008b).
It is expected that year-to-year variability would not cause significant differences in the modeled health impacts, and hence would justify needing to subject the full set of receptors to only one year of meteorological data. This conclusion is based on modeling sensitivity analyses that were carried out by ARB staff using five years of meteorological data for the Stockton area (See Appendix F). The five annual average concentration patterns were compared with one another and with the average predictions for the full five-year period. Differences between these were found to be negligible in terms of spatial concentration patterns, locations of highest concentrations, and absolute concentrations. Therefore, whether five-year or one-year meteorological data are used, the modeling results show similar estimated exposures and potential cancer risks surrounding the railyard facility. Furthermore, due to the proximity of the San Diego-Beardsley Station to the BNSF San Diego Railyard, a single year of meteorological data is sufficient to represent the site.

Figure IV-1 shows the annual wind rose plot for the meteorological data used in BNSF San Diego Railyard air dispersion modeling, and Figure IV-2 shows the wind class frequency distribution. Cancer risk isopleths, such as determined by AERMOD for the BNSF San Diego Railyard, are expected to be skewed in the direction to which the prevailing winds are blowing. The prevailing winds for the wind rose are from the west-northwest in the region, so the cancer risk isopleths would be expected to be skewed to the east-southeast. However, this is not the case: the cancer risk isopleths for the BNSF San Diego Railyard (See Figure II-2 and Figure II-4) are strongly skewed to the southwest.

Wind rose: a rose-like shape plot that depicts wind speed and direction patterns to illustrate prevailing wind conditions.

Further examination of the wind data and the railyard operations data shows a more complex situation. The wind rose shown in Figure IV-1 presents annual average wind pattern over a 24-hour period around the BNSF San Diego Railyard, with a strong sea breeze penetration and significant off-shore wind flows from inland, averaging 1.83 meters per second. Figure IV-3 presents the annual wind rose plot for the diurnal wind flow, from 8AM to 6PM. The diurnal wind flow is dominated by the westerly sea breeze penetration, with a relatively higher average wind speed at 2.61 meters per second. The nocturnal wind field, on the other hand, is dominated by off-shore flows, starting a transition during the early night hours (7PM to 11PM: See annual wind rose plot in Figure IV-4) and shifting wind direction to the northeast from midnight to 7AM (See annual wind rose plot in Figure IV-5). The nocturnal wind field has relatively lower wind speeds, averaging 1.26 meters per second from 7PM to 11PM and 1.1 meters per second from midnight to 7AM.

Closer scrutiny of the railyard operations data shows that line-haul operations, which are responsible for 88% of diesel PM emissions (see Table II-2), take place in the late evening and early morning hours. This is done in order to avoid commuter traffic.

Switcher operations, responsible for only 10% of diesel PM emissions, take place during daytime hours (BNSF, 2008).

Both the diurnal wind flow (dominated by the sea breeze penetration) and the nocturnal wind flow (dominated by the off-shore flows) have shown strong effects on the air transport and dispersion around and near the BNSF San Diego Railyard. During daytime hours, when switcher operations occur, the higher wind speed from the sea breeze penetration, the higher surface roughness over inland, and higher diurnal mixing height produce relatively lower air concentrations downwind (i.e., inland areas) as a result of higher dispersion and dilution, as compared to oceanic areas. During nighttime hours, however, when the line-haul operations occur, the lower wind speed from nocturnal off-shore wind flows, the lower nighttime mixing height, and the small surface roughness over off-shore areas have a lower air dispersion effect on the surface air flow, so the air concentrations downwind (i.e., to the southwest) become relatively higher. The lower air dispersion effect during nighttime hours, combined with the fact that line-haul operations take place during the late evening and early morning hours, explain the southwest skew of the cancer risk isopleths.

The detailed procedures of meteorological data preparation and the QA/QC are also documented in the air dispersion modeling report (ENVIRON, 2008b), and the wind class frequency distributions for the meteorological data used for the air dispersion modeling in this study.

Figure IV-1: Wind Rose for BNSF San Diego Railyard

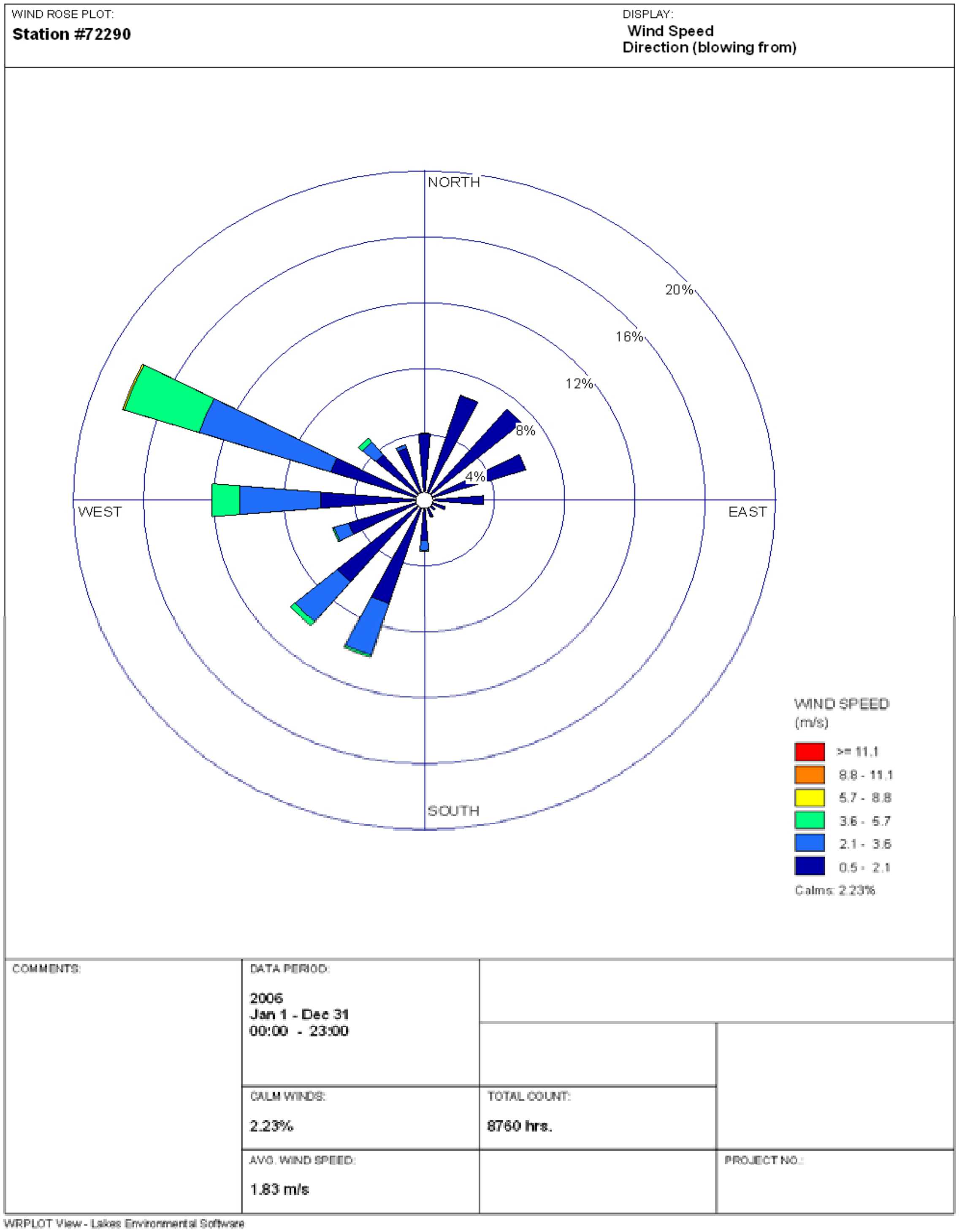


Figure IV-2: Wind Class Frequency Distribution for BNSF San Diego Railyard

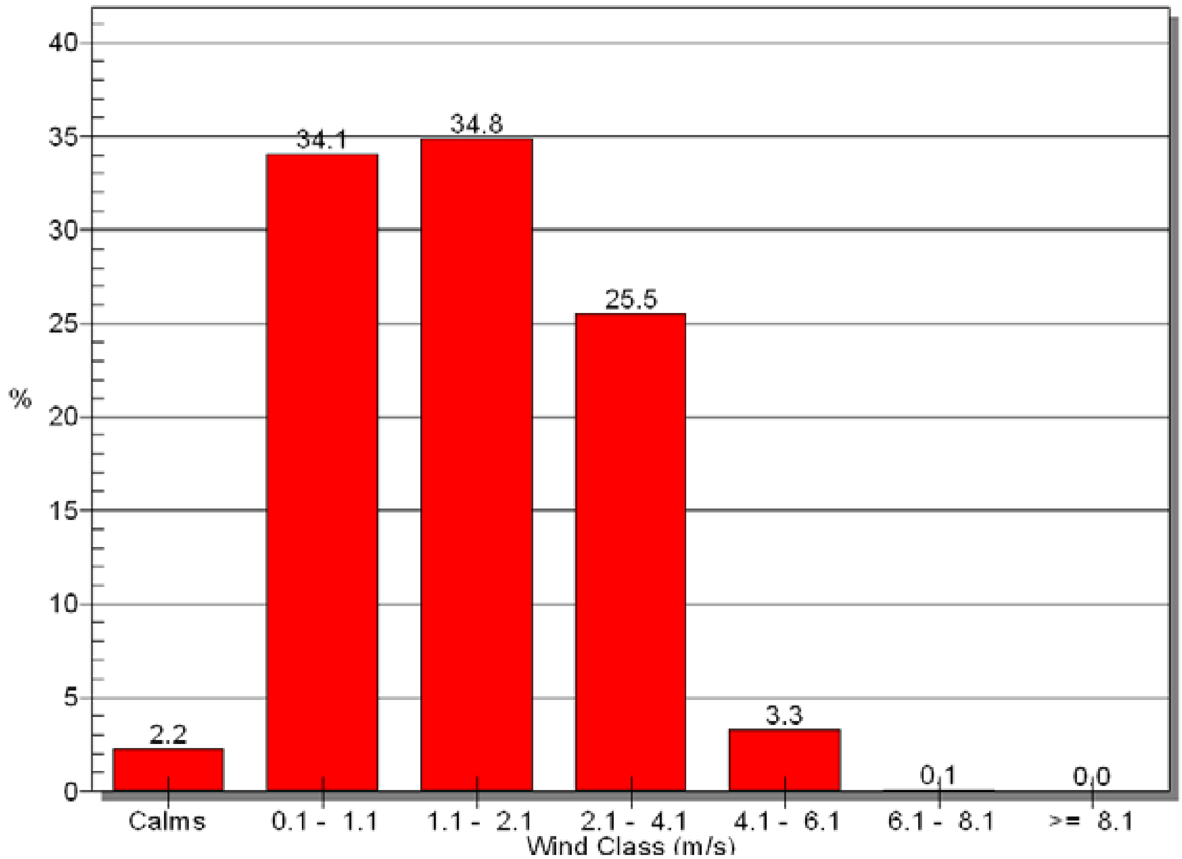


Figure IV-3: Diurnal (8AM to 6PM) Wind Rose for BNSF San Diego Railyard

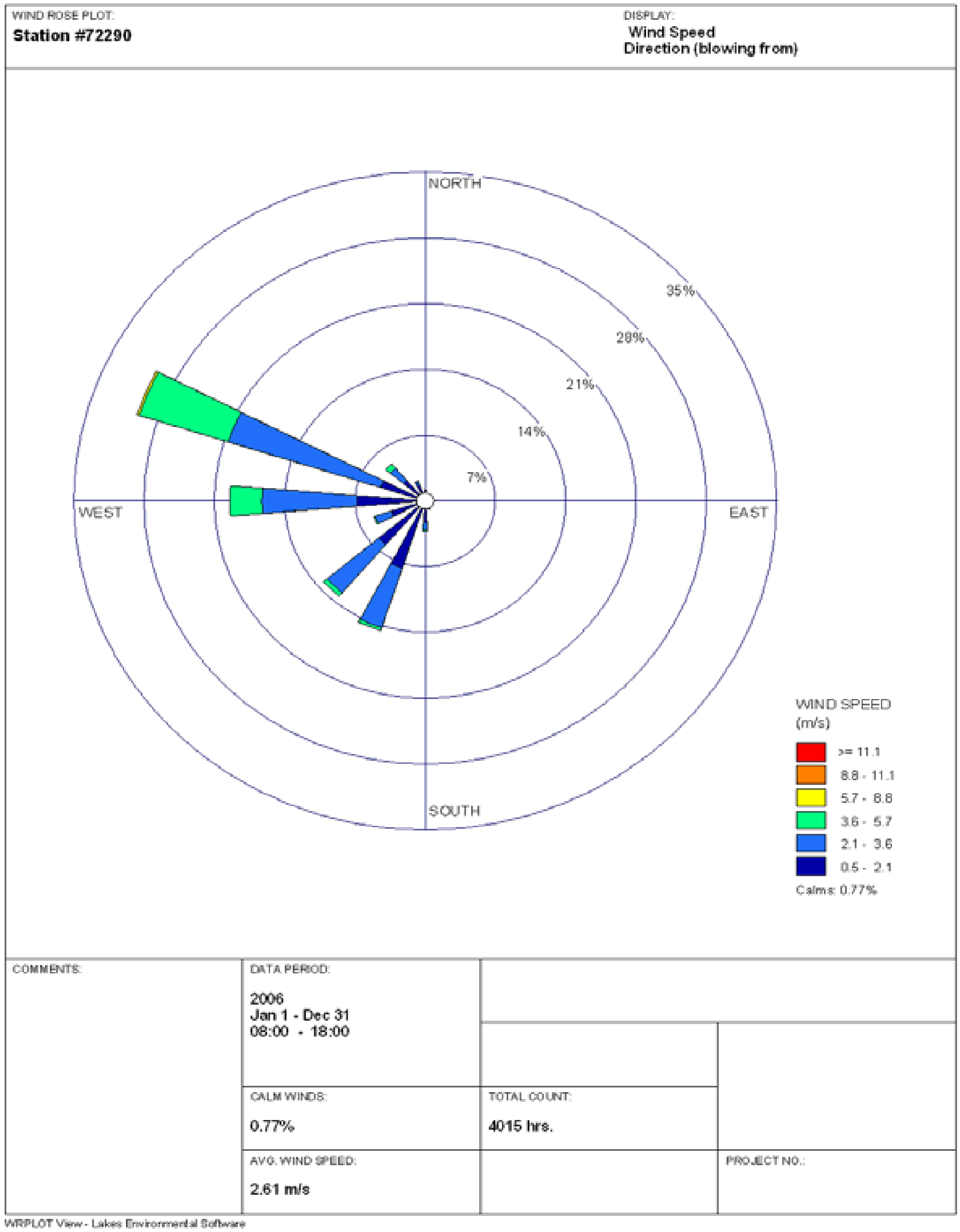
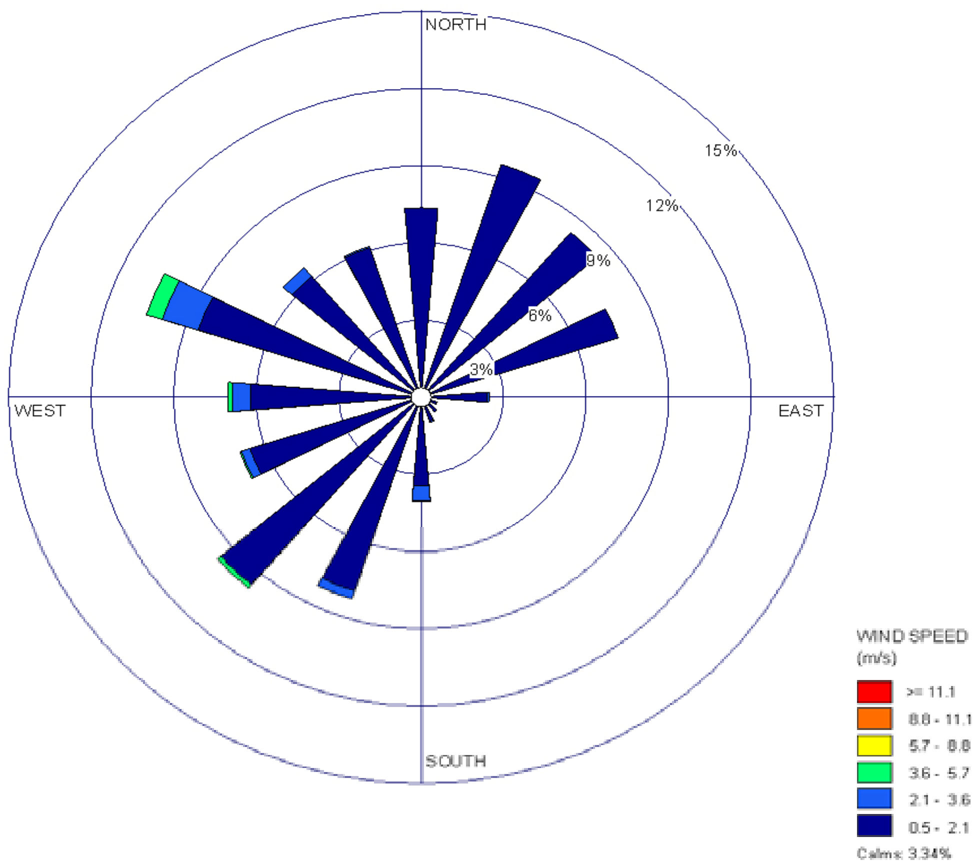


Figure IV-4: Early Nocturnal (7PM to 11PM)
Wind Rose for BNSF San Diego Railyard

WIND ROSE PLOT:
Station #72290

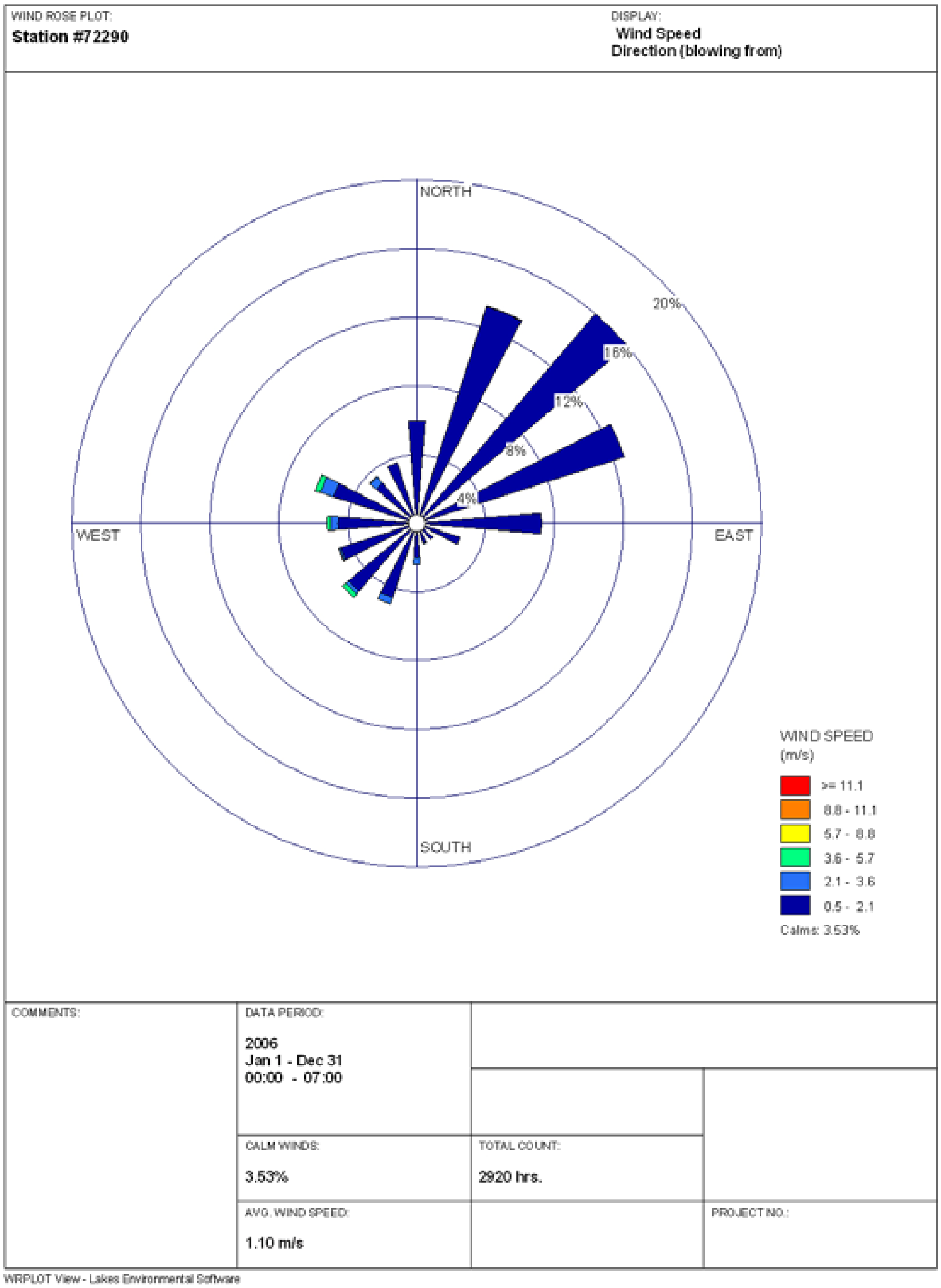
DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD: 2006 Jan 1 - Dec 31 19:00 - 23:00		
	CALM WINDS: 3.34%	TOTAL COUNT: 1825 hrs.	
	AVG. WIND SPEED: 1.26 m/s		PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure IV-5: Late Nocturnal (Midnight to 7AM) Wind Rose for BNSF San Diego Railyard



D. Model Receptors

Receptors are the defined discrete locations where concentrations are estimated by the dispersion model. In this study, Cartesian grid receptor network is used, in which an array of points is identified by their *x* (east-west) and *y* (north-south) coordinates. This receptor network is capable of identifying the emission sources within the railyard with respect to the receptors in the nearby residential areas.

According to the ARB Railyard *Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006b), the modeling domain is defined as a 20 km x 20 km region, which covers the railyard in the center of domain and extends to the surrounding areas. To better characterize different dispersive levels of concentrations from the railyard, ENVIRON used three sets of discrete Cartesian receptor grid points around the facility. The spacing and sized of the Cartesian receptor grids were determined based on a screening sensitivity analysis. The Cartesian receptors used in model simulations included a fine grid with spacing of 50 meters surrounding the BNSF San Diego Railyard for modeling within approximately 500 meters of the fenceline, a medium receptor grid with a spacing of 250 meters out to a distance of approximately 1,500 meters from the fenceline, and a coarse receptor grid with spacing of 500 meters out to approximately five kilometers from the fenceline. Figures IV-6, IV-7, and IV-8 show the locations of the fine, medium, and coarse grid receptor networks, respectively (ENVIRON Report).

Figure IV-6: Fine Grid Receptor Network Air Dispersion Modeling for BNSF San Diego Railyard

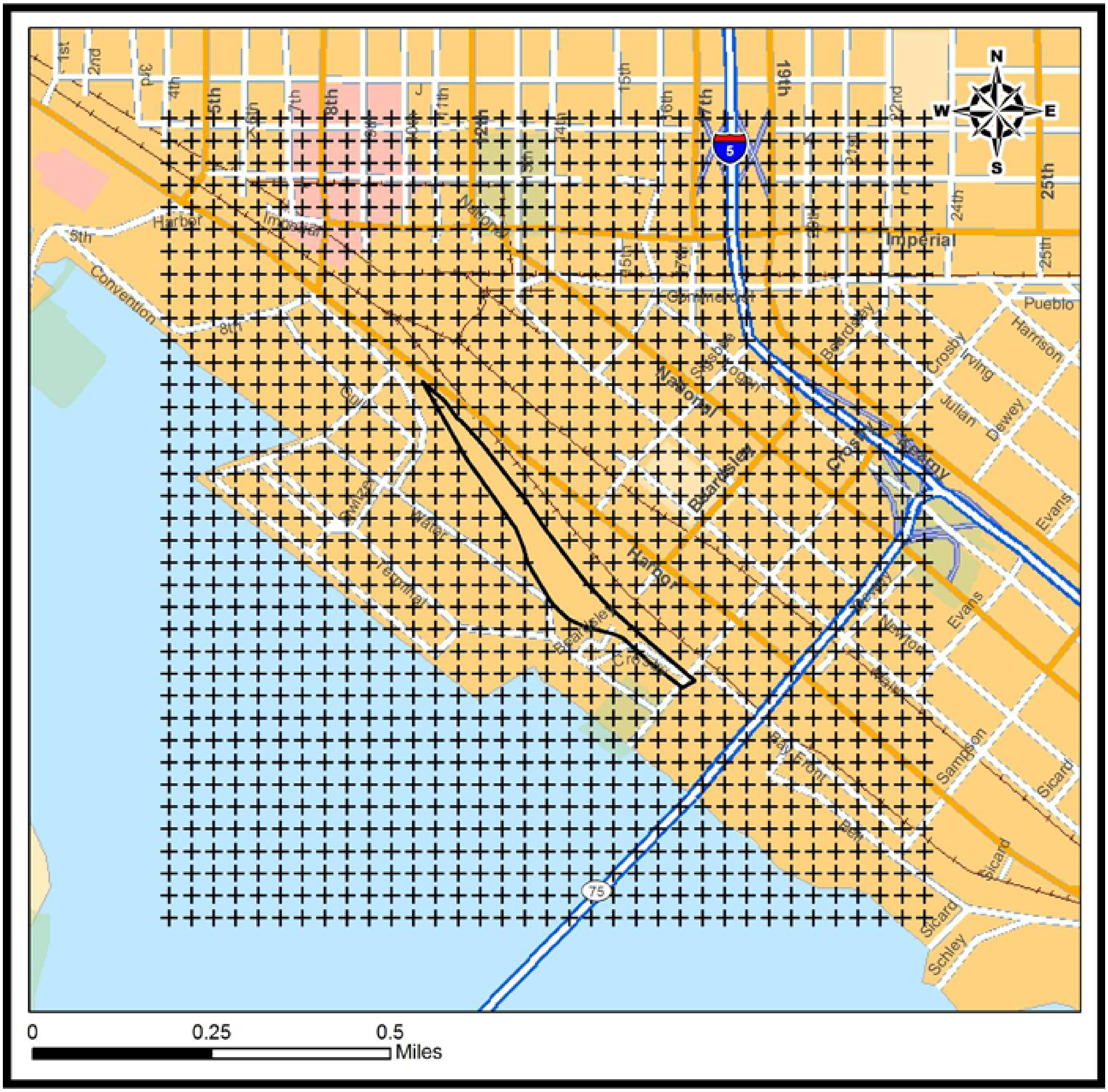


Figure IV-7: Medium Grid Receptor Network Air Dispersion Modeling for BNSF San Diego Railyard

Figure IV-8: Coarse Grid Receptor Network Air Dispersion Modeling for BNSF San Diego Railyard

E. Building Wake Effects

If pollutant emissions are released at or below the "Good Engineering Practice" height as defined by EPA Guidance (U.S. EPA, 1985), the plume dispersion may be affected by surrounding facility buildings and structures. The aerodynamic wakes and eddies produced by the buildings or structures may cause pollutant emissions to be mixed more rapidly to the ground, causing elevated ground level concentrations. The AERMOD model has the *Plume Rise Model Enhancements* option to account for potential building-induced aerodynamic downwash effects. Although UP included building wake effects in their modeling analyses, BNSF conducted a sensitivity analysis and found that the building wake effect has an insignificant impact on the diesel PM air concentrations for the railyard (ENVIRON, 2006b). Detailed treatment of building wake effects is documented in the ENVIRON air dispersion modeling report (ENVIRON, 2008b).

F. Model Implementation Inputs

AERMOD requires four types of basic implementation inputs: control, source, meteorological, and receptor. Control inputs are required to specify the global model options for the model run. Source inputs require source identification and source type (point or volume). Each source type requires specific parameters to define the source. The required inputs for a point source are emission rate, release height, emission source diameter, exhaust exit temperature, and exhaust exit velocity.

Meteorological and receptor inputs have been discussed in Sections C and D. The requirements and the format of input files to the AERMOD are documented in the user's guide of AERMOD (US EPA, 2004a). The model input files for this study are provided in the ENVIRON Report.

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V. HEALTH RISK ASSESSMENT OF BNSF SAN DIEGO RAILYARD

This chapter describes the ARB's guidelines on health risk assessment and characterization of potential cancer and non-cancer risks associated with exposure to toxic air contaminants, especially diesel PM, emitted within and surrounding the BNSF San Diego Railyard. In addition, the detailed health risk assessment results are presented, and the associated uncertainties are discussed qualitatively.

A. ARB Railyard Health Risk Assessment (HRA) Guidelines

The BNSF San Diego Railyard Health Risk Assessment (HRA) follows *The Air Toxics Hot Spots Program Risk Assessment Guidelines* published by the Office of Environmental Health Hazard Assessment (OEHHA), and is consistent with the *Roseville Railyard Study* (ARB, 2004a) performed by ARB staff. The OEHHA Guidelines outline a tiered approach to risk assessment, providing risk assessors with flexibility and allowing for consideration of site-specific differences:

- Tier 1: a standard point-estimate approach that uses a combination of the average and high-end point-estimates.
- Tier 2: utilizes site-specific information for risk assessment when site-specific information is available and is more representative than the Tier 1 point-estimates.
- Tier 3: a stochastic approach for exposure assessment when the data distribution is available.
- Tier 4: also a stochastic approach, but allows for utilization of site-specific data distribution.

> **Percentile:** Any one of the points dividing a distribution of values into parts each of which contain 1/100 of the values. For example, the 65th percentile breathing rate is a value such that the breathing rates from 65% of population are less or equal to it.

The HRA is based on the yard specific emission inventory and air dispersion modeling predictions. The OEHHA Guidelines recommend that all health hazard risk assessments adopt a Tier-1 evaluation for the Hot Spots Program, even if other approaches are also presented. Two point-estimates of breathing rates in Tier-1 methodology are used in this HRA, one representing an average and the other representing a high-end value based on the probability distribution of breathing rate. The average and high-end of point-estimates are defined as 65th percentile and 95th percentile from the distributions identified in the OEHHA Guidelines (OEHHA, 2000). In 2004, ARB recommended the interim use of the 80th percentile value (the midpoint value of the 65th and 95th percentile breathing rates referred as an estimate of central tendency) as the minimum value for risk management decisions at residential receptors for the breathing intake (ARB, 2004b). The 80th

percentile corresponds to a breathing rate of 302 liters / kilogram-day (302 L / kg-day) from the probability distribution function. As indicated by the OEHHA Guidelines, the Tier-1 evaluation is useful in comparing risks among a number of facilities and similar sources.

The ARB has also developed the *Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006b) to help ensure that the air dispersion modeling and health risk assessment performed for each railyard meet the OEHHA Guidelines.

B. Exposure Assessment

Exposure assessment is a comprehensive process that integrates and evaluates many variables. Three process components have been identified to have significant impacts on the results of a health risk assessment – emissions, meteorological conditions, and exposure duration of nearby residents. The emissions have a linear effect on the risk levels, given meteorological conditions and defined exposure duration. Meteorological conditions can also have a critical impact on the resultant ambient concentration of a toxic pollutant, with higher concentrations found along the predominant wind direction and under calm wind conditions. An individual's proximity to the emission plume, how long he or she breathes the emissions (exposure duration), and the individual's breathing rate play key roles in determining potential risk. The longer the exposure time for an individual, the greater the estimated potential risk for the individual. The risk assessment adopted in this study generally assumes that the receptors will be exposed to the same toxic levels for 24 hours per day for 70 years. If a receptor is exposed for a shorter period of time to a given pollutant concentration of diesel PM, the cancer risk will proportionately decrease. Children have a greater risk than adults because they have greater exposure on a per unit body weight basis, and also because of other factors.

Diesel PM is not the only TAC emitted from the BNSF San Diego Railyard. Some of the track maintenance equipment at the railyard runs on liquefied petroleum gas (LPG) and compressed natural gas (CNG). The total organic gases are estimated at about 0.01 tons per year, or 30 pounds per year, compared to 1.67 tons per year of diesel emissions in the railyard.

The total organic gases are speciated according to ARB Speciate Profile #2105 for exhaust emissions and ARB Speciate Profile #422 for evaporative emissions. Most of the toxic air contaminants in the total organic gases are not identified as carcinogen according to the OEHHA Guidelines (OEHHA, 2003). When the exhaust and evaporative emissions profiles are combined, benzene, formaldehyde, and 1,3-butadiene are the only toxic air contaminants among the top five cancer contributors, and total about 0.7 pounds per year. Calculation of potency weighted emissions for the on-site toxic air contaminants (see a similar analysis for off-site contaminants in Table V-1) shows a substantially lower level of potential cancer risk, about a factor of 38,000 less than the cancer risk level for diesel PM. Hence, only diesel PM emissions are presented in the on-site emission analysis. Detailed emission inventories and analysis are provided in the ENVIRON Report.

ARB staff also evaluated other toxic air contaminant emissions around the BNSF San Diego Railyard. Within a one-mile distance of the railyard, 32 stationary toxic air contaminant sources were identified. For the year 2005, the total emissions of toxic air contaminants other than diesel PM emitted from stationary sources within a one-mile distance from the railyard are estimated at about 213 tons per year. Over 60 toxic air contaminant species are identified among these emissions, in which isopropyl alcohol, n-butyl alcohol, and xylenes are three major contributors with emissions estimated at 74, 63, and 14 tons per year, respectively.

Not all of these toxic air contaminants are identified as carcinogens. According to ARB's *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (ARB, 2000), diesel PM, 1,3-butadiene, benzene, carbon tetrachloride, and formaldehyde are defined as the top five cancer risk contributors, based on ambient concentrations. These toxic air contaminants account for 95% of the State's estimated potential cancer risk levels. This study also concluded that diesel PM contributes over 70% of the State's estimated potential cancer risk levels, significantly higher than other toxic air contaminants (ARB, 2000). Among the off-site toxic air contaminant emissions for the BNSF San Diego Railyard, the top five cancer risk contributors (without diesel PM) are estimated at about 1.3 tons per year.

The Office of Environmental Health Hazard Assessment (OEHHA) has estimated an inhalation **cancer potency factor** for individual chemicals and some chemical mixtures such as whole diesel exhaust. Diesel PM contains many individual cancer-causing chemicals. The individual cancer-causing chemicals are not separately evaluated so as to avoid double counting. The four compounds listed here – 1,3-butadiene, benzene, carbon tetrachloride, and formaldehyde – are given a weighting factor by comparing each compound's cancer potency factor to the diesel PM cancer potency factor. This factor is multiplied by the estimated emissions for that compound, which gives the potency weighted estimated toxic emissions as shown in Table V-1. As can be seen, the potency weighted estimated toxic emissions for these toxic air contaminants are de minimis, at about 0.04 tons per year, and are therefore not included in this report. Hence, the health impacts in this study primarily focus on the risks from the diesel PM emissions.

Cancer potency factors are expressed as the 95% upper confidence limit of excess cancer cases occurring in an exposed population assuming continuous lifetime exposure to a substance at a dose of one milligram per kilogram of body weight, and are expressed in units of $(mg/kg\text{-}day)^{-1}$.

Table V-1: Potency Weighted Estimated Toxic Emissions from Significant Off-Site Stationary Sources Surrounding BNSF San Diego Railyard

Compound	Cancer Potency Factor	Weighted Factor	Estimated Emissions (Tons Per Year)	Potency Weighted Estimated Toxic Emissions (Tons Per Year)
Diesel PM	1.1	1	11.6	**11.6**
1,3-Butadiene	0.6	0.55	0.001	**0.0005**
Benzene	0.1	0.09	0.24	**0.02**
Carbon Tetrachloride	0.15	0.14	0	**0**
Formaldehyde	0.021	0.02	1.03	**0.02**
Total (non-diesel PM)			**1.3**	**0.04**

In addition, ARB staff evaluated the potential cancer risk levels caused by the use of gasoline in the San Diego Air Basin. Table V-2 shows the emissions of four major carcinogenic toxic air contaminants from San Diego Air Basin gasoline sources in 2005 (ARB, 2006c). As indicated in Table V-2, the potency weighted emissions of these four toxic air contaminants from all types of gasoline sources are estimated at about 209 tons per year, or about 12% of diesel PM emissions in the San Diego Air Basin. If only gasoline-powered vehicles are considered, the potency weighted emissions of these four toxic air contaminants are estimated at about 100 tons per year, or about 6% of diesel PM emissions in the Basin. Hence, gasoline-powered vehicular sources are not included in the analysis.

Table V-2: Emissions of Major Toxic Air Contaminants from Use of Gasoline in the San Diego Air Basin

Compound	Toxic Air Contaminant Emissions (Tons Per Year)			
	From All Sources	Potency Weighted*	From Gasoline Vehicles	Potency Weighted*
Diesel PM	*1,800*	***1,800***	-	-
1,3-Butadiene	190	**104**	97	**53**
Benzene	849	**76**	460	**41**
Formaldehyde	1,240	**25**	250	**5**
Acetaldehyde	497	**4**	72	**0.6**
Total (non-diesel PM)	**2,776**	**209**	**879**	**100**

*Based on cancer potency weighted factors.

The relationship between a given level of exposure to diesel PM and the cancer risk is estimated by using the diesel PM cancer potency factor. A description of how the diesel cancer potency factor was derived can be found in the document entitled *Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant* (ARB, 1998); and a shorter description can be found in the *Air Toxics Hot Spot Program Risk Assessment Guidelines, Part II, Technical Support Document for Describing Available Cancer Potency Factors* (OEHHA, 2002). The use of the diesel PM cancer potency factor for assessing cancer risk is described in the OEHHA Guidelines (OEHHA, 2003). The potential cancer risk is estimated by multiplying the inhalation dose by the cancer potency factor of diesel PM, i.e., $1.1(mg/kg\text{-}day)^{-1}$.

C. Risk Characterization

Risk characterization is defined as the process of obtaining a quantitative estimate of risk. The risk characterization process integrates the results of air dispersion modeling and relevant toxicity data (e.g., diesel PM cancer potency factor) to estimate potential cancer or non-cancer health impacts associated with contaminant exposure.

Exposures to pollutants that were originally emitted into the air can also occur in different pathways as a result of breathing, dermal contact, ingestion of contaminated produce, and ingestion of fish that have taken up contaminants from water bodies. These exposures can all contribute to an individual's health risk. However, diesel PM risk is evaluated by the inhalation pathway only in this study because the risk contributions by other pathways of exposure are insignificant relative to the inhalation pathway. It should be noted that the background or ambient diesel PM concentrations are not incorporated into the risk quantification in this study. Therefore, the estimated potential health risk in the study should be viewed as the risk level above the risk due to background impacts.

Because the risk characterization is an integrated process from a series of procedures, the overall associated uncertainties are also linked to the uncertainty from each procedural component. Additional details and associated uncertainty on the risk characterization are provided in the OEHHA Guidelines (OEHHA, 2003), and discussed in Section D.

In the following sections, the predicted cancer and non-cancer risk levels resulting from on-site and off-site emissions are presented.

D. Risk Characterization Associated with On-Site Emissions

1. Potential Cancer Risk

The potential cancer risk levels associated with the estimated diesel PM emissions at the BNSF San Diego Railyard are displayed by **isopleths**, based on the 80th percentile breathing rate and 70-year exposure duration for residents. In this study, ARB staff elected to present the cancer risk isopleths focusing on risk levels of 10, 25, 50, and 100 in a million. Figure V-1 and Figure V-2 present these isopleths. Figure V-1 focuses on the near source risk levels; Figure V-2 illustrates the more regional impacts. In each figure, the risk isopleths are overlaid onto a satellite image of the area surrounding the BNSF San Diego Railyard, to better illustrate the land use (residential, commercial, industrial, or mixed use) of these impacted areas.

> An **isopleth** is a line drawn on a map through all points of equal value of some measurable quantity; in this case, cancer risk.

The OEHHA Guidelines require that for health risk assessments, the cancer risk for the maximum exposure at the point of maximum impact should be reported. The point of maximum impact (PMI), which is defined as a location or the receptor point with the highest cancer risk level outside of the railyard boundary, with or without residential exposure, is predicted to be located at the northeast side of the railyard fence line. The PMI is downwind of high emission density areas for the prevailing west-northwesterly wind, where about 95% percent of facility-wide diesel PM emissions were generated (see the emission allocation in Appendix E).

The estimated cancer risk at the PMI is about 330 chances per million for the 70-year exposure. The land use in the vicinity of the PMI is primarily zoned for transportation and industrial use. In the residential zoned area, to the northeast of the railyard, the potential cancer risk of maximally exposed individual resident (MEIR) or maximum individual cancer risk (MICR) is estimated at about 70 chances in a million.

As indicated by the *Roseville Railyard Study* (ARB, 2004a), the location of the PMI may vary depending upon the settings of the model inputs and parameters, such as meteorological data set or emission allocations in the railyard. Therefore, given the estimated emissions, modeling settings, and the assumptions applied to the risk assessment, there are great uncertainties associated with the estimation of the PMI and MICR. These indications should not be interpreted as a literal prediction of disease incidence but more as a tool for comparison. In addition, the estimated point of maximum impact location and maximum individual cancer risk value may not be replicated by air monitoring.

ARB staff also conducted a comparison of cancer risks estimated at the PMI versus MICR, and the differences of facility-wide diesel PM emissions between the UP and

BNSF railyards. The ratios of cancer risks at the PMI or MICR to the diesel PM emissions do not suggest that one railroad's facilities have statistically higher cancer risks than the other railroad's or vice versa. Rather, the differences are primarily due to emission spatial distributions from individual operations among railyards.

Figure V-1 and Figure V-2 show the isopleths of cancer risk from on-site diesel PM emissions based on the 80th percentile breathing rate approach. At the BNSF San Diego Railyard property boundaries, the estimated potential cancer risk is about 100 chances per million. Beyond the railyard boundaries, the estimated potential cancer risks decrease rapidly to about 50 chances per million, and the risks further decrease to 25 in a million within about a mile from the railyard, then to 10 in a million within another mile distance in downwind area.

It is important to understand that these risk levels represent the predicted risks (due to the BNSF San Diego Railyard diesel PM emissions) above the existing background risk levels. For the broader San Diego Air Basin, the estimated regional background risk level is estimated to be about 420 in a million caused by diesel PM and about 600 in a million caused by all toxic air pollutants in the year 2000 (ARB, 2006c).

Figure V-1: Estimated Near-Source Cancer Risk (Chances per Million People) from the BNSF San Diego Railyard

Figure V-2: Estimated Regional Cancer Risk (Chances per Million People) from the BNSF San Diego Railyard

The OEHHA Guidelines recommend a 70-year lifetime exposure duration to evaluate the potential cancer risks for residents. Shorter exposure duration of 30 years and 9 years are also recommended for residents and school-age children, respectively, as a supplement. These three exposure durations – 70 years, 30 years, and 9 years – all assume exposure for 24 hours a day, and 7 days a week. It is important to note that children, for physiological as well as behavioral reasons, have higher rates of exposure than adults on a per unit body weight basis (OEHHA, 2003).

To evaluate the potential cancer risks for workers, the OEHHA Guidelines recommend that a 40-year exposure duration be used, assuming workers have a different breathing rate (149 L kg^{-1} day^{-1}) and exposure for an 8-hour workday, five days a week, 245 days a year.

Table V-3 shows the equivalent risk levels of 70- and 30-year exposure durations for exposed residents; and 40- and 9-year exposure durations for workers and school-age children, respectively. As Table V-3 shows, the 10 in a million isopleth line in Figure V-2 would become 4 in a million for exposed population with a shorter residency of 30 years, 2.5 in a million exposed school-age children, and 2 in a million for off-site workers.

To conservatively communicate the risks, ARB staff presents the estimated cancer risk isopleths all based on a 70-year resident exposure duration, even for those impacted industrial areas where no resident lives.

Table V-3: Equivalent Potential Cancer Risk Levels for 70-, 40-, 30-, and 9-Year Exposure Durations

Exposure Duration (years)	Equivalent Estimated Cancer Risk Levels (chances in a million)			
70	10	25	50	100
30	4	11	21	43
9*	2.5	6.3	12.5	25
40‡	2	5	10	20

* Exposure duration for school-age children, age 0-9.
‡ Exposure duration for off-site workers: work schedule 8 hours a day, 5 days a week, 245 days a year.

The populated areas near the BNSF San Diego Railyard are located to the northeast of the railyard. Areas located northwest and southeast of the railyard are predominantly commercial/industrial. Southwest of the railyard is the San Diego Harbor. Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated risks above 10 chances in a million levels encompasses approximately 2,250 acres where about 16,500 residents live. Table V-4 presents the exposed population and area coverage size for various impacted zones of cancer risks.

Table V-4: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels (Assumes a 70-Year Exposure)

Estimated Risk (Per Million)	Estimated Impacted Area (Acres)	Estimated Exposure (Population)
10 - 25	1,540	13,300
25 - 50	430	2,680
50 - 100	190	560
> 100	90	0
> 10	**2,250**	**16,500**

2. Potential Non-Cancer Chronic Risk

The quantitative relationship between the amount of exposure to a substance and the incidence or occurrence of an adverse health impact is called the dose-response assessment. According to the OEHHA Guidelines (OEHHA, 2003), dose-response information for non-carcinogens is presented in the form of reference exposure levels. OEHHA has developed chronic reference exposure levels for assessing non-cancer health impacts from long-term exposure.

A chronic reference exposure level is a concentration level, expressed in units of micrograms per cubic meter ($\mu g/m^3$) for inhalation exposure, at or below which no adverse health effects are anticipated following long-term exposure. Long-term exposure for these purposes has been defined as 12% of a lifetime, or about eight years for humans (OEHHA, 2003).

The methodology for developing chronic reference exposure levels is fundamentally the same as that used by U.S. EPA in developing the inhalation reference concentrations and oral reference doses. Chronic reference exposure levels are frequently calculated by dividing the no observed adverse effect level or lowest observed adverse effect levels in human or animal studies by uncertainty factors (OEHHA, 2003).

A substantial number of epidemiologic studies have found a strong association between exposure to ambient particulate matter and adverse health effects. For diesel PM, OEHHA has determined a chronic reference exposure level of 5 µg/m^3, with the respiratory system as the hazard index target (OEHHA, 2003).

It should be emphasized that exceeding the chronic reference exposure level does not necessarily indicate that an adverse health impact will occur. However, levels of exposure above the reference exposure level have an increasing but undefined probability of resulting in an adverse health impact, particularly in sensitive individuals (e.g., depending on the toxicant, the very young, the elderly, pregnant women, and those with acute or chronic illnesses).

The significance of exceeding the reference exposure level is dependent on the seriousness of the health endpoint, the strength and interpretation of the health studies, the magnitude of combined safety factors, and other considerations (OEHHA, 2003).

It is important to note that reference exposure level for diesel PM is essentially the U.S. EPA Reference Concentration first developed in the early 1990s based on histological changes in the lungs of rats. Since the identification of diesel PM as a toxic air contaminant, California has evaluated the latest literature on particulate matter health effects to set the Ambient Air Quality Standard. Diesel PM is a component of particulate matter. Health effects from particulate matter in humans include illness and death from cardiovascular and respiratory disease, and exacerbation of asthma and other respiratory illnesses. Additionally, a body of literature has been published, largely after the identification of diesel PM as a toxic air contaminant and adoption of the reference exposure level, which shows that diesel PM can enhance allergic responses in humans and animals. Thus, it should be noted that the reference exposure level does not reflect adverse impacts of particulate matter on cardiovascular and respiratory disease and deaths, exacerbation of asthma, and enhancement of allergic response.

The hazard index is then calculated by taking the annual average diesel PM concentration, and dividing by the chronic reference exposure level of 5 µg/m^3. A hazard index value of 1 or greater indicates an exceedance of the chronic reference exposure level.

As part of this study, ARB staff conducted an analysis of the potential non-cancer health impacts associated with exposures to the model-predicted levels of directly emitted diesel PM from on-site sources within the modeling domain. The hazard index values are calculated, and then plotted as a series of isopleths in Figure V-3. As can be seen, the hazard index is ~ 0.1 at the railyard boundary, and <0.1 around the vicinity of the railyard. According to the OEHHA Guidelines (OEHHA, 2003), these levels indicate that the potential non-cancer chronic public health risks are less likely to happen.

Figure V-3 presents the spatial distribution of estimated non-cancer chronic risks by health hazard index isopleths that range from 0.01 to 0.10 around the yard facility. The zone of impact where non-cancer chronic health hazard indices are above 0.01 is an estimated area of 1,270 acres.

Figure V-3: Estimated Non-Cancer Chronic Risk Levels (Hazard Index) from the BNSF San Diego Railyard

3. Non-Cancer Acute Risk

According to the OEHHA guidelines, an acute reference exposure level is an exposure that is not likely to cause adverse health effects in a human population, including sensitive subgroups, exposed to that concentration for the specified exposure duration (generally one hour) on an intermittent basis. Non-cancer acute risk characterization involves calculating the maximum potential health impacts based on short-term acute exposure and reference exposure levels. Non-cancer acute impacts for a single pollutant are estimated by calculating a hazard index.

Due to the uncertainties in the toxicological and epidemiological studies, diesel PM as a whole was not assigned a short-term acute reference exposure level. It is only specific compounds of diesel exhaust (e.g., acrolein) that independently have potential acute effects (such as irritation of the eyes and respiratory tract), and an assigned acute reference exposure level. However, acrolein is primarily used as a chemical intermediate in the manufacture of adhesives and paper. It has also been found as a byproduct of any burning process, such as fire, and tobacco smoke. Acrolein is a chemically reactive and unstable compound, and easily reacts with a variety of chemical compounds in the atmosphere. Compared to the other compounds in the diesel exhaust, the concentration of acrolein has a much lower chance of reaching a distant off-site receptor. More importantly, given the multitude of activities ongoing at facilities as complex as railyards, there are much higher levels of uncertainties associated with hourly-specific emission data and hourly model-estimated peak concentrations for short-term exposure, which are essential to assess acute risk. Therefore, non-cancer acute risk is not addressed quantitatively in this study. From a risk management perspective, ARB staff believes it is reasonable to focus on diesel PM cancer risk because it is the predominant risk driver, and the most effective parameter to evaluate risk reduction actions. Moreover, actions to reduce diesel PM will also reduce non-cancer risks.

E. Risk Characterization Associated with Off-Site Emissions

1. Cancer Risk

ARB staff evaluated the impacts from off-site pollution sources near the BNSF San Diego Railyard facility using the U.S. EPA-approved AERMOD dispersion model. Specifically, off-site mobile and stationary diesel PM emission sources located within a one-mile distance from the railyard were included. Diesel PM off-site emissions used in the off-site modeling runs consisted of about 11.6 tons per year – 6.0 tons per year from roadways and 5.6 tons per year from stationary facilities – representing emissions for 2005. The diesel PM emissions from the BNSF San Diego Railyard are not analyzed in the off-site air dispersion modeling. The same meteorological data and coarse receptor grid system used for on-site air dispersion modeling was used for the off-site modeling runs. The estimated potential cancer risks from the off-site emissions are presented in Figure V-4.

The zone of impact of estimated cancer risks associated with off-site diesel PM emissions is much larger as compared to that associated with the BNSF San Diego Railyard diesel PM emissions. Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated potential cancer risks above 10 chances in a million levels associated with off-site diesel PM emissions encompasses approximately 160,000 acres where about 20,200 residents live, while the zone of impact for the same level of potential cancer risk (more than 10 chances in a million) associated with railyard diesel PM emissions covers about 2,250 acres where approximately 16,500 residents live.

Figure V-4: Estimated Potential Cancer Risk Near the BNSF San Diego Railyard (Off-Site)

Table V-5 presents the exposed population and area coverage size for various impacted zones of cancer risks associated with off-site diesel PM emissions.

Table V-5: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels from Off-Site Emissions Near the BNSF San Diego Railyard

Estimated Risk (Per Million)	Estimated Impacted Area (Acres)	Estimated Exposure (Population)
10 - 25	79,400	12,200
25 - 50	41,000	4,100
50 - 100	18,300	2,210
> 100	21,700	1,660
> 10	**160,000**	**20,200**

Detailed calculations and methodologies used in off-site air dispersion modeling are presented in Appendix C.

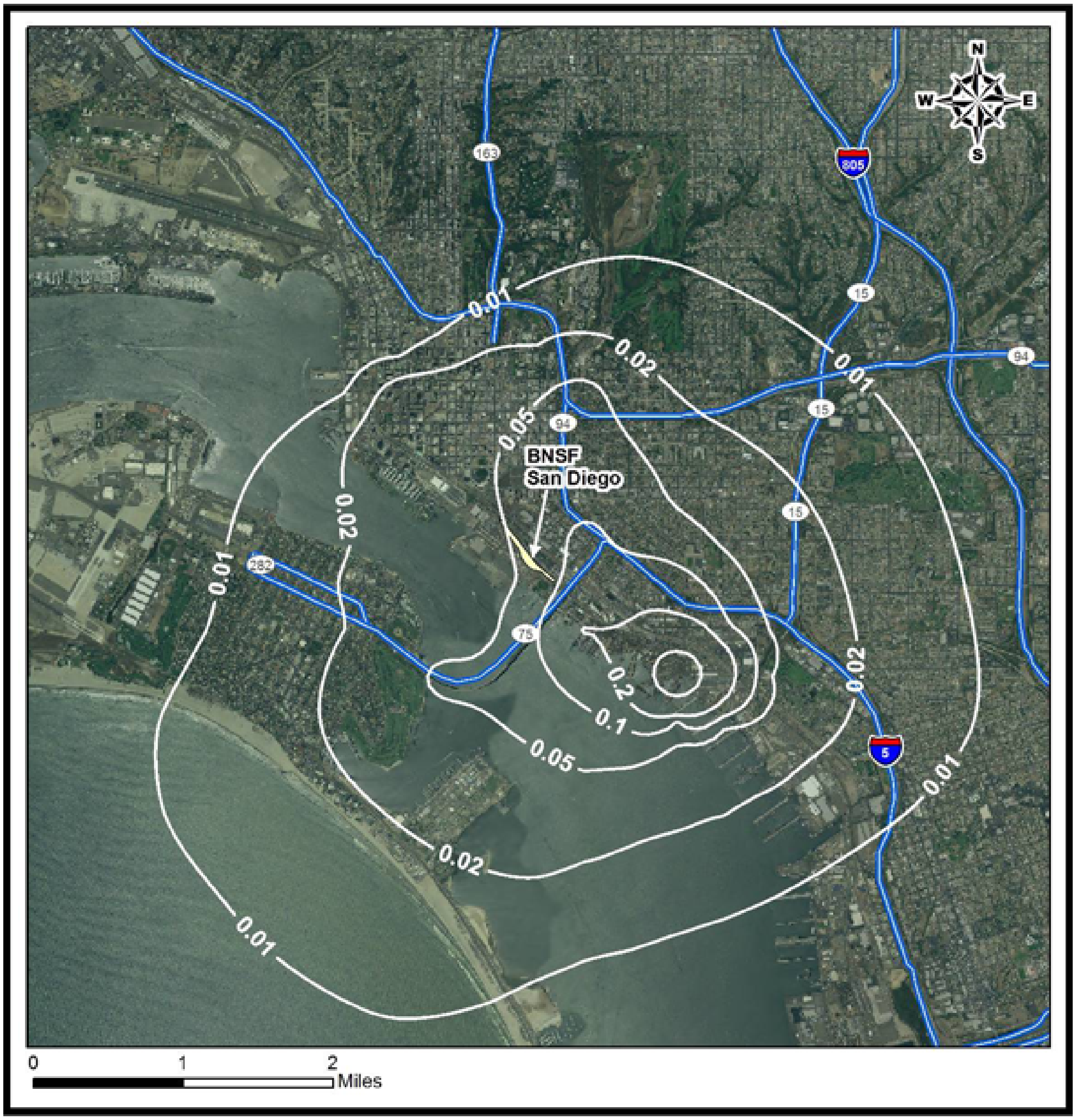
2. Non-Cancer Chronic Risk

The non-cancer chronic risks (indicated as hazard indices) from the off-site diesel PM emissions are presented in Figure V-5. For the residential areas around the railyard, the risk levels are estimated to range from 0.01 to 0.2. The areas adjacent to I-5 and SR-75 show higher chronic risks as compared to other areas. About 42% of off-site mobile diesel PM emissions is linked to these major traffic roadways in the region.

The zone of impact of estimated non-cancer risks associated with off-site diesel PM emissions is much larger as compared to that associated with the BNSF San Diego Railyard diesel PM emissions. The zone of impact of the estimated potential non-cancer chronic risk associated with off-site diesel PM emissions encompasses approximately 12,800 acres with a hazard index above 0.01, while the zone of impact for the same level of potential non-cancer chronic risk (hazard index above 0.01) associated with railyard diesel PM emissions covers about 1,270 acres.

The estimated range of hazard indices in the region suggests that the non-cancer health risks are less likely to occur.

Figure V-5: Estimated Non-Cancer Chronic Risk Levels (Hazard Index) from Off-site Emissions Near the BNSF San Diego Railyard



F. Risks to Sensitive Receptors Surrounding the BNSF San Diego Railyard

Some individuals may be more sensitive to toxic exposures than the general population. These sensitive populations may be identified as school-age children and seniors. There are 23 sensitive receptors within a one-mile distance of the BNSF San Diego Railyard, including 8 schools, 9 pre-schools / child care centers, and 6 hospitals /

clinics. Table V-4 shows the number of sensitive receptors in various levels of cancer risk associated with diesel PM emissions from the BNSF San Diego Railyard based on 70-year residential exposure duration. There are 8 receptors are located at the impacted zone with a potential cancer risk from 10 to 25 in a million, 4 in the zone of 25 to 50 in a million, and 4 in the zone of 50 to 100 in a million.

Table V-6: Estimated Number of Sensitive Receptors in Various Levels of Cancer Risks Associated with On-Site Diesel PM Emissions

Estimated Cancer Risk (Chances in a Million)	70-Year Exposure
100	0
50 – 100	4
25 – 50	4
10 – 25	8
> 10	16

G. Uncertainty and Limitations

Risk assessment is a complex procedure which requires the integration of many variables and assumptions. The estimated diesel PM concentrations and risk levels produced by a risk assessment are based on several assumptions, many of which are designed to be health protective so that potential risks to individual are not underestimated.

As described previously, the health risk assessment consists of three components: (1) emission inventory, (2) air dispersion modeling, and (3) risk assessment. Each component has a certain degree of uncertainty associated with its estimation and prediction due to the assumptions made. Therefore, there are uncertainties and limitations with the results.

The following subsections describe the specific sources of uncertainties in each component. In combination, these various factors may result in potential uncertainties in the location and magnitude of predicted concentrations, as well as the potential health effects actually associated with a particular level of exposure.

1. Emission Inventory

Emissions are usually estimated by consideration of the operational activities and fuel consumption associated with emission factors based on source tests. There are some uncertainties with the emission estimates. These uncertainties of emission estimates may be attributed to many factors such as a lack of information for variability of locomotive engine type, throttle setting, level of maintenance, operation time, and emission factor estimates. Quantifying individual uncertainties is a complex process and may in itself introduce unpredictable[3].

For locomotive sources at the BNSF San Diego Railyard, the activity rates include primarily the number of engines in operation and the time spent in different power settings. The methodology used for the locomotive emissions is based on these facility-specific activity data. The number of engines operating in the facility is generally well-tallied by BNSF's electronic monitoring of locomotives entering and leaving the railyard. However, the monitoring under certain circumstances may produce duplicate readings that can result in overestimates of locomotive activity. In addition to recorded activity data, surveys and communications with facility personnel, and correlations from other existing data, (e.g., from the *Roseville Railyard Study* (ARB, 2004a)), all were used to verify the emission estimations in the emission inventory.

Uncertainties also exist in estimates of the engine time in mode. Idling is typically the most significant operational mode, but locomotive event recorder data cannot distinguish when an engine is on or off during periods when the locomotive is in the idling notch. As a result, a professional judgment is applied to distinguish between these two modes. While the current operations may not be precisely known, control measures already being implemented are expected to result in reduced activity levels and lower emissions than are estimated here for future years.

As discussed previously, emission factors are often used for emission estimates according to different operating cycles. The *Roseville Railyard Study* (ARB, 2004a)

[3] Tier-1 methodology is a conservative point approach but suitable for the scope of the current HRAs, , given the condition and lack of probability data. The Tier-1 approach used in the HRAs is consistent with the previous health risk analyses performed by ARB, the *Roseville Railyard Study* (ARB, 2004a) and *Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, Final Report* (ARB, 2006d). By recognizing associated uncertainties or variability, the HRAs have qualitatively discussed the limitations and caveats of possible underestimation and overestimation in emission inventory and modeling predictions because of assumptions and simplifications. The discussion provides an additional reference for HRA results, even though quantitative uncertainty bounds are unavailable. Most importantly, it is not practical to characterize and quantify the uncertainty of estimated health risks without the support of robust scientific data and actual probability distribution functions of model variables. An attempt to incorporate subjective judgments on uncertainty analyses can lead to misinterpretation of HRA findings.

developed representative diesel PM emission factors for locomotives in different duty cycles. To reduce the possible variability of the locomotive population and the uncertainty from assumptions, the emission factors were updated in the study to cover a wide range of locomotive fleet in the State (see Appendix D). The fuel usage in the locomotives in 2005 is calculated from BNSF's annual fuel consumption database. These critical updates for locomotive emission inventory have established the most representative locomotive emission factors for the study.

For non-locomotive emissions, uncertainty associated with vehicles and equipment at the railyard facility also exists because the duty cycles (i.e., engine load demanded) are less well-characterized. Default estimates of the duty cycle parameters may not accurately reflect the typical duty demanded from these vehicles and equipment at any particular site. In addition, national and state regulations have targeted these sources for emission reductions. Implementation of these rules and fleet turnover to newer engines meeting more strict standards should significantly reduce emissions at these rail sites in future years. However, the effects of these regulations have not been incorporated in the emission estimates, so estimated emissions are greater than those expected for future years at the same activity level.

2. Air Dispersion Modeling

An air dispersion model is derived from atmospheric diffusion theory with assumptions or, alternatively, by solution of the atmospheric-diffusion equation assuming simplified forms of effective diffusivity. Within the limits of the simplifications involved in its derivation, the model-associated uncertainties are vulnerably propagated into its downstream applications.

Model uncertainty may stem from data gaps that are filled by the use of assumptions. Uncertainty is often considered as a measure of the incompleteness of one's knowledge or information about a variate whose true value could be established if a perfect measurement is available. The structure of mathematical models employed to represent scenarios and phenomena of interest is often a key source of model uncertainty, due to the fact that models are often only a simplified representation of a real-world system, such as the limitation of model formulation, the parameterization of complex processes, and the approximation of numerical calculations. These uncertainties are inherent and exclusively caused by the model's inability to represent a complex aerodynamic process. An air dispersion model usually uses simplified atmospheric conditions to simulate pollutant transport in the air, and these conditions become inputs to the models (e.g., the use of non site-specific meteorological data, uniform wind speed over the simulating domain, use of surface parameters for the meteorological station as opposed to the railyard, substitution of missing meteorological data, and simplified emission source representation). There are also other physical dynamics in the transport process, such as the small-scale turbulent flow in the air, which are not characterized by the air dispersion models. As a result of the simplified representation of real-world physics, deviations in pollutant concentrations predicted by the models may occur due to the introduced uncertainty sources.

The other type of uncertainty is referred as reducible uncertainty, a result of uncertainties associated with input parameters of the known conditions, which include source characteristics and meteorological inputs. However, the uncertainties in air dispersion models have been improved over the years because of better representations in the model structure. In 2006, the U.S. EPA modeling guidance was updated to replace the Industrial Source Complex model with AERMOD as a recommended regulatory air dispersion model for determining single source and source complex. Many updated formulations have been incorporated into the model structure from its predecessor, ISCST3, for better predictions from the air dispersion process. Nevertheless, quantifying overall uncertainty of model predictions is infeasible due to the associated uncertainties described above, and is beyond the scope of this study.

3. Risk Assessment

The toxicity of toxic air contaminants is often established by available epidemiological studies, or, where data from humans are not available, the use of data from animal studies. The diesel PM cancer potency factor is based on long-term study of railyard workers exposed to diesel exhaust at concentrations approximately ten times typical ambient exposures (OEHHA, 2003). The differences within human populations usually cannot be easily quantified and incorporated into risk assessments. Factors including metabolism, target site sensitivity, diet, immunological responses, and genetics may influence the response to toxicants. In addition, the human population is much more diverse both genetically and culturally (e.g., lifestyle, diet) than inbred experimental animals. The intraspecies variability among humans is expected to be much greater than in laboratory animals. Adjustment for tumors at multiple sites induced by some carcinogens could result in a higher potency. Other uncertainties arise (1) in the assumptions underlying the dose-response model used, and (2) in extrapolating from large experimental doses, where, for example, other toxic effects may compromise the assessment of carcinogenic potential due to much smaller environmental doses. Also, only single tumor sites induced by a substance are usually considered. When epidemiological data are used to generate a carcinogenic potency, less uncertainty is involved in the extrapolation from workplace exposures to environmental exposures. However, children, whose hematological, nervous, endocrine, and immune systems are still developing and who may be more sensitive to the effects of carcinogens, are not included in the worker population and risk estimates based on occupational epidemiological data are more uncertain for children than adults.

Human exposures to diesel PM are based on limited availability of data and are mostly derived based on estimates of emissions and duration of exposure. Different epidemiological studies also suggest somewhat different levels of risk. When the Scientific Review Panel identified diesel PM as a toxic air contaminant (ARB, 1998), the panel members endorsed a range of inhalation cancer potency factors [1.3 x 10^{-4} to 2.4 x 10^{-3} $(\mu g/m^3)^{-1}$] and a risk factor of $3x10^{-4}$ $(\mu g/m^3)^{-1}$, as a reasonable estimate of the unit risk. From the unit risk factor an inhalation cancer potency factor of 1.1 $(mg/kg\text{-}day)^{-1}$ can be calculated, which is used in the study. There are many epidemiological studies that support the finding that diesel exhaust exposure elevates relative risk for lung cancer. However, the quantification of each uncertainty applied in the estimate of cancer potency is very difficult and can be itself uncertain

This study adopts the standard Tier 1 approach recommended by OEHHA for exposure and risk assessment. A Tier 1 approach is an end-point estimate methodology without the consideration of site-specific data distributions. It also assumes that an individual is exposed to an annual average concentration of a pollutant continuously for a specific time period. OEHHA recommends the lifetime 70-year exposure duration with a 24-hour per day exposure be used for determining residential cancer risks. This will ensure a person residing in the vicinity of a facility for a lifetime will be included in the evaluation of risk posed by the facility. Lifetime 70-year exposure is a conservative estimate, but is the historical benchmark for comparing facility impacts on receptors and for evaluating the effectiveness of air pollution control measures.

Although it is not likely that most people will reside at a single residence for 70 years, it is common that people will spend their entire lives in a major urban area. While residing in urban areas, it is very possible to be exposed to the emissions of another facility at the next residence. In order to help ensure that people do not accumulate an excess unacceptable cancer risk from cumulative exposure to stationary facilities at multiple residences, the 70-year exposure duration is used for risk management decisions. However, if a facility is notifying the public regarding health risk, it is a useful indication for a person who has resided in his or her current residence for less than 70 years to know that the calculated estimate of his or her cancer risk is less than that calculated for a 70-year risk (OEHHA, 2003). It is important that the risk estimates generated in this study not be interpreted as the expected rates of disease in the exposed population, but rather as estimates of potential risk. Risk assessment is best viewed as a comparative tool rather than a literal prediction of diesel incidence in a community.

Moreover, since the Tier-1 methodology is used in the study for the health risk assessment, the results have been limited to deterministic estimates based on conservative inputs. For example, an 80^{th} percentile breathing rate approach is used to represent a 70-year lifetime inhalation that tends toward the high end for the general population. Moreover, the results based on the Tier-1 estimates do not provide an indication of the magnitude of uncertainty surrounding the quantities estimated, nor an insight into the key sources of underlying uncertainty.

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APPENDIX A

METHODOLOGY FOR ESTIMATING OFF-SITE DIESEL PM MOBILE SOURCE EMISSIONS

INTRODUCTION

This assessment includes on-road mobile emissions from all heavy-duty diesel truck running exhaust as it is the primary source of diesel particulate emissions within the on-road vehicle fleet. Traditionally, on-road mobile emission inventories are generated at the county scale using California's emission factor model EMFAC and then allocated to large grid cells using the Direct Travel Impact Model. To enhance the spatial resolution, ARB staff estimated emissions based on roadway specific vehicle activity data and allocated them to individual roadway links. All roadway links within a 2-mile buffer of the combined Commerce yards and all links within a 1-mile buffer of all other yards are included in this assessment. This inventory does not include emissions generated by idling of heavy-duty trucks or any off-road equipment outside the railyards.

As more work has been done to understand transportation modeling and forecasting, access to local scale vehicle activity data has increased. For example, the various Metropolitan Planning Organizations (MPOs) are mandated by the Federal government to maintain a regional transportation plan and a regional transportation improvement plan. These reports assess the impact the travel growth and assess various transportation improvement plans[4]. Planning is based on travel activity results from Transportation Demand Models that forecast traffic volumes and other characteristics of the transportation system. Currently, more than a dozen MPOs as well as the California Department of Transportation (Caltrans) maintain transportation demand models.

Through a system of mathematical equations, Transportation Demand Models estimate vehicle population and activity estimates such as speed and vehicle miles traveled based on data about population, employment, surveys, income, roadway and transit networks, and transportation costs. The activity is then assigned a spatial and temporal distribution by allocating them to roadway links and time periods. A roadway link is defined as a discrete section of roadway with unique estimates for the fleet specific population and average speed and is classified as a freeway, ramp, major arterial, minor arterial, collector, or centroid connector. Link-based emission inventory development utilizes these enhanced spatial data and fleet and pollutant specific emission factors to estimate emissions at the neighborhood scale.

METHODOLOGY

The methodology for estimating emissions from on-road mobile sources outside the railyards was broken into four main processes and described below. The first step involves gathering vehicle activity data specific to each link on the roadway network. Each link contains 24 hours worth of activity data including vehicle miles traveled,

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[4] Southern California Association of Governments Transportation Modeling, http://www.scag.ca.gov/modeling/ (Accessed January 2007).

vehicle type, and speed. The activity is then apportioned to the various heavy-duty diesel truck types (Table 1) where speed-specific vehicle miles traveled is then matched to an emission factor from EMFAC to estimate total emissions from each vehicle type for each hour of the day. EMFAC2007 was used for this assessment.

Table A-1: Heavy-Duty Truck Categories

Class	Description	Weight (GVW)	Abbreviation	Technology Group
T4	Light Heavy-Duty Diesel Trucks	8,501-10,000	LHDDT1	DIESEL
T5	Light Heavy-Duty Diesel Trucks	10,001-14,000	LHDDT2	DIESEL
T6	Medium Heavy-Duty Diesel Trucks	14,001-33,000	MHDDT	DIESEL
T7	Heavy Heavy-Duty Diesel Trucks	33,001+	HHDDT	DIESEL

Step 1: Obtain Link-Specific Activity Data

The link specific activity data for heavy-duty trucks necessary to estimate emissions are speed and vehicle miles traveled, where vehicle miles traveled is a product of vehicle volume (population) and link length. Link activity for Ventura, Los Angeles, Orange, and more than 90% of Riverside and San Bernardino counties are provided by the Southern California Association of Governments' Heavy-Duty Truck Transportation Demand Model. Heavy-duty truck activity is modeled using truck specific data, commodity flows and goods movement data. The Southern California Association of Governments, however, is the only MPO with a heavy-duty truck model. The remaining counties under the railyard study are covered by the Integrated Transportation Network developed by Alpine Geophysics[5]. The Integrated Transportation Network was developed by stitching together MPO transportation networks and the Caltrans statewide transportation network. Link specific truck activity from the Integrated Transportation Network is estimated as a fraction of the total traffic on the links and is based on the fraction of trucks within each county as it is estimated in EMFAC.

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[5] Wilkinson, James (Alpine Geophysics); et al. "Development of the California Integrated Transportation Network (ITN)," Alpine Geophysics – Atmospheric and Hydrologic Sciences, La Honda, CA (2004). http://www.arb.ca.gov/airways/CCOS/docs/III3_0402_Jun06_fr.pdf

The product of truck volume and link length is referred to as vehicle miles traveled (VMT) and has units of miles. Transportation demand models provide total VMT for each link without further classification into the various heavy-duty truck weight and fuel type classifications. Therefore, in order to assess the emissions only from heavy-duty diesel trucks, the total heavy-duty truck VMT is multiplied by the fraction of trucks that are diesel. Once the total diesel VMT is calculated, the heavy-duty truck diesel VMT is multiplied by the fraction of trucks that make up the four weight classifications. The fuel and weight fractions are specific to each county and are derived from total VMT for each weight and fuel class in EMFAC for each county. The data are then compiled into an activity matrix (Table 2) composed of a link identification code, hour of the day, speed, light heavy-duty diesel 1 truck (LHDDT1) VMT, light heavy-duty diesel 2 truck (LHDDT2) VMT, medium heavy-duty diesel truck (MHDDT) VMT, and heavy heavy-duty diesel truck (HHDDT) VMT.

Table A-2: Activity Matrix Example

LINKID	Hour	Speed (mph)	LHDDT1 VMT (miles)	LHDDT2 VMT (miles)	MHDDT VMT (miles)	HHDDT VMT (miles)
49761	12	45	0.37	0.48	3.17	5.51
49761	3	45	0.14	0.18	1.16	2.00
49761	3	35	0.16	0.21	1.37	2.38
50234	4	55	0.19	0.26	1.68	2.92

Step 2: Derive Gram per Mile Emission Factors

The second step of the emission inventory process involves developing emission factors for all source categories for a specified time period, emission type, and pollutant. Running exhaust emission factors based on vehicle type, fuel type, and speed were developed from the Emfac mode of EMFAC. These are composite emission factors based on the model year distribution for each county and provided in units of grams of emissions per mile traveled. Finally, a matrix of emission factors by speed and vehicle type was assembled for each county for light heavy-duty diesel trucks 1 and 2 (LHDDT1 and LHDDT2), medium heavy-duty diesel trucks (MHDDT) and heavy heavy-duty diesel trucks (HHDDT). The following is an example of such a matrix (Table 3):

Table A-3: Emission Factor Matrix Example

Speed (mph)	Diesel PM Emission Factors (g/mile)			
	LHD1 DSL	LHD2 DSL	MHD DSL	HHD DSL
12	0.101	0.145	0.631	2.371
20	0.072	0.105	0.455	1.277
45	0.037	0.054	0.235	0.728
60	0.033	0.047	0.206	1.095

Step 3: Calculate Emissions

Diesel particulate matter (PM) emission factors are provided as grams per mile specific to each speed and heavy-duty truck type (see table above). To estimate emissions, the activity for each diesel heavy-duty truck type was matched to the corresponding emission factor (EF). For example, a 0.25 mile long link at 3 am in the morning has 8 heavy heavy-duty diesel trucks (HHDDTs) traveling at 45 miles per hour. This equates to a VMT of 2.00 miles (8 trucks*0.25 miles). EMFAC has provided a gram per mile emission factor for HHDDT traveling at 45 mph in Los Angeles County as 0.728 grams diesel PM / mile. In order to estimate total emissions from HHDDTs on that link during that hour of the day the following calculation is made:

$$TotalEmissions(grams) = EF \cdot (Volume \cdot LinkLength) = EF \cdot VMT$$

$$TotalEmissions(grams) = EF \cdot VMT = 0.728 \frac{grams}{mile} \cdot 2.00 miles = 1.45 grams$$

The steps outlined above and in Steps 1 and 2 can be represented with this single equation that provides an emissions total for each link for each hour of the day.

$$Emissions = VMT_{link} \cdot \sum_{i,j} Fraction_{i,j} \cdot EF_{i,j}$$

where:

- Emissions – the total emissions in grams for each link
- i – represents the individual diesel heavy-duty truck types (LHDDT1, LHDDT2 – light heavy-duty diesel trucks 1 and 2; MHDDT – medium heavy-duty diesel truck; and HHDDT – heavy heavy-duty diesel truck)
- j – represent the hours of the day (hours 1-24)

- VMT_{Link} - total VMT for that link for all heavy-duty trucks (gasoline and diesel)
- Fraction = the fraction of the VMT that is attributable to each diesel heavy-duty truck type The fraction is estimated based on VMT estimates in EMFAC: Example: $VMT_{MHDDT}/VMT_{\text{all heavy-duty trucks (gasoline \& diesel)}}$
- EF = the heavy-duty diesel truck emission factors. The emission factor is vehicle type and speed specific and is thus matched according to the link specific activity parameters.

From this expression, diesel particulate matter emissions are provided for each link and for each hour of the day. Finally, emissions are summed for all links for all hours of the day to provide a total daily emission inventory.

Step 4: QA/QC – Quality Assurance/Quality Control

To assure that the total emissions were calculated correctly, the total emissions (grams) were divided by the total diesel VMT to estimate a composite diesel gram per mile emission factor. This back-calculated emission factor was checked against emission factors in EMFAC. In addition, where possible, heavy-duty truck gate counts provided for the railyards were checked against traffic volumes on the links residing by the gates.

LIMITATIONS AND CAVEATS

ARB staff made several important assumptions in developing this inventory. While these assumptions are appropriate at the county level they may be less appropriate for the particular areas modeled in this assessment. For example, the county specific default model year distribution within EMFAC and vehicle type VMT fractions were assumed to be applicable for all links within the domain modeled. In the vicinity of significant heavy heavy-duty truck trip generators, it is reasonable to expect that surrounding links will also have higher heavy heavy-duty truck fractions. In these cases, using EMFAC county vehicle mix fractions may underestimate the total diesel particulate emissions from on-road heavy duty trucks. In this inventory, EMFAC county defaults were employed as there is insufficient data available to assess the vehicle mix fractions surrounding the railyards.

Travel demand model results are checked by comparing actual traffic counts on links where the majority of vehicle travel takes place. Therefore, there will be greater uncertainty associated with activity from minor arterials, collectors, and centroid connectors than from higher volume freeways. Data based strictly on actual traffic counts for each street would provide better activity estimates, but unfortunately very little data is available for such an analysis. While links representing freeways are accurately allocated spatially, the allocation of neighborhood streets and other minor roads are not as well represented.

The emissions inventory developed for this study only included diesel particulate matter emissions from running exhaust as it is the primary diesel source from on-road mobile sources. Emissions from other modes such as off-road equipment, extended idling, starts, and off-road equipment outside the rail yards were excluded. Vehicle activity from distribution centers, rail yards and ports, however, are included as they are captured on the roadway network by the travel demand models.

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APPENDIX B

METHODOLOGY FOR ESTIMATING OFF-SITE DIESEL PM STATIONARY SOURCE EMISSIONS

Emissions from off-site stationary source facilities were identified using the California Emission Inventory Development and Reporting System (CEIDARS) database, which contains information reported by the local air districts for stationary sources within their jurisdiction.

Geographic information system (GIS) mapping tools were used to create a one-mile buffer zone outside the property boundary footprint reported for each railyard. The CEIDARS facilities whose latitude/longitude coordinates fell within the one-mile buffer zone were selected.

The reported criteria pollutants in CEIDARS include carbon monoxide, nitrogen oxides, sulfur oxides, total organic gases, and particulate matter (PM). The reported toxic pollutants include the substances and facilities covered by the Air Toxics “Hot Spots” (AB 2588) program. Diesel exhaust particulate matter (diesel PM) was estimated from stationary internal combustion engines burning diesel fuel, operating at stationary sources reported in CEIDARS. Diesel PM emissions were derived from the reported criteria pollutant PM that is ten microns or less in diameter (criteria pollutant PM_{10}) emitted from these engines. In a few cases, diesel exhaust PM was reported explicitly under the “Hot Spots” reporting provisions as a toxic pollutant, but generally the criteria pollutant PM_{10} reported at diesel internal combustion engines was more comprehensive than the toxics inventory, and was, therefore, the primary source of data regarding diesel PM emissions.

The CEIDARS emissions represent annual average emission totals from routine operations at stationary sources. For the current analysis, the annual emissions were converted to grams per second, as required for modeling inputs for cancer and chronic non-cancer risk evaluation, by assuming uniform temporal operation during the year. (The available, reported emission data for acute, maximum hourly operations were insufficient to support estimation of acute, maximum hour exposures).

The CEIDARS 2004 database year was used to provide the most recent data available for stationary sources. Data for emissions, location coordinates, and stack/release characteristics were taken from data reported by the local air districts in the 2004 CEIDARS database wherever available. However, because microscale modeling requires extensive information at the detailed device and stack level that has not been routinely reported, historically, by many air districts, much of the stack/release information is not in CEIDARS. Gaps in the reported data were addressed in the following ways. Where latitude/longitude coordinates were not reported for the stack/release locations, prior year databases were first searched for valid coordinates, which provided some additional data. If no other data were available, then the coordinates reported for the overall facility were applied to the stack locations. Where parameters were not complete for the stack/release characteristics (i.e., height, diameter, gas temperature and velocity), prior year databases were first searched for valid data. If no reported parameters were available, then U.S. EPA stack defaults from the Emissions Modeling System for Hazardous Air Pollutants (EMS-HAP) program were assigned. The U.S. EPA stack defaults are assigned based on the Source Classification Code (SCC) or Standard Industrial Classification (SIC) code of the operation. If an applicable U.S. EPA default was not available, then a final generic default was applied. To ensure that the microscale modeling results would be health-protective, the generic release parameters assumed relatively low height and buoyancy. Two generic defaults were used. First, if the emitting process was identifiable as a vent or other fugitive-type release, the default parameters assigned were a height of five feet, diameter of two feet, temperature of 100 degrees Fahrenheit, and velocity of 25 feet per second. For all remaining unspecified and unassigned releases, the final generic default parameters assigned were a height of twenty feet, diameter of two feet, temperature of 100 degrees Fahrenheit, and velocity of 25 feet per second. All English units used in the CEIDARS database were converted to metric units for use in the microscale modeling input files.

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APPENDIX C

IMPACTS FROM OFF-SITE DIESEL PM EMISSION SOURCES

Impacts from off-site pollution sources near the BNSF San Diego Railyard facility were modeled using the USEPA-approved AERMOD dispersion model version 07026. Specifically, off-site mobile and stationary diesel PM emission sources located out to a distance of one mile from the perimeter of the BNSF San Diego Railyard were included. Other emission sources that were located immediately beyond the one-mile zone from the facility, such as a high-volume freeway, have the potential to impact receptors in the modeling grid, but were not considered.

To facilitate modeling of these off-site emission sources, the information summarized in Table 1 was provided by external sources.

Table 1: Data Provided by Others for Off-Site Emission Source Modeling

Type of Data	Description	Data Source
Emission Estimates	Off-site diesel PM emissions for 2005 Mobile Sources: 6.0 TPY diesel PM Stationary Sources: 5.6 TPY diesel PM	PTSD/MSAB
Receptor Grid	41x41 Cartesian grid covering 121 km^2 with uniform spacing of 500 meters. Grid origin: (480400, 3612700) in UTM Zone 11.	ENVIRON
Meteorological Data	AERMET-Processed data for 2006 *Surface*: Beardsley Station and Lindbergh Field *Upper Air*: San Diego Miramar	ENVIRON
Surface Data	Albedo: 0.14 – 0.34 Bowen Ratio: 0.78 – 6.29 Surface Roughness: 0.22 – 1.56	ENVIRON

The spatial and temporal emissions provided for these sources were converted into the appropriate AERMOD ready files. The off-site emissions were modeled using the same coarse receptor grid and meteorological data used by the consultants for their railyard model runs, as indicated in the table above.

Figure 1: Region Surrounding the BNSF San Diego Railyard Facility (Modeling Domain Indicated by the Black Outline)

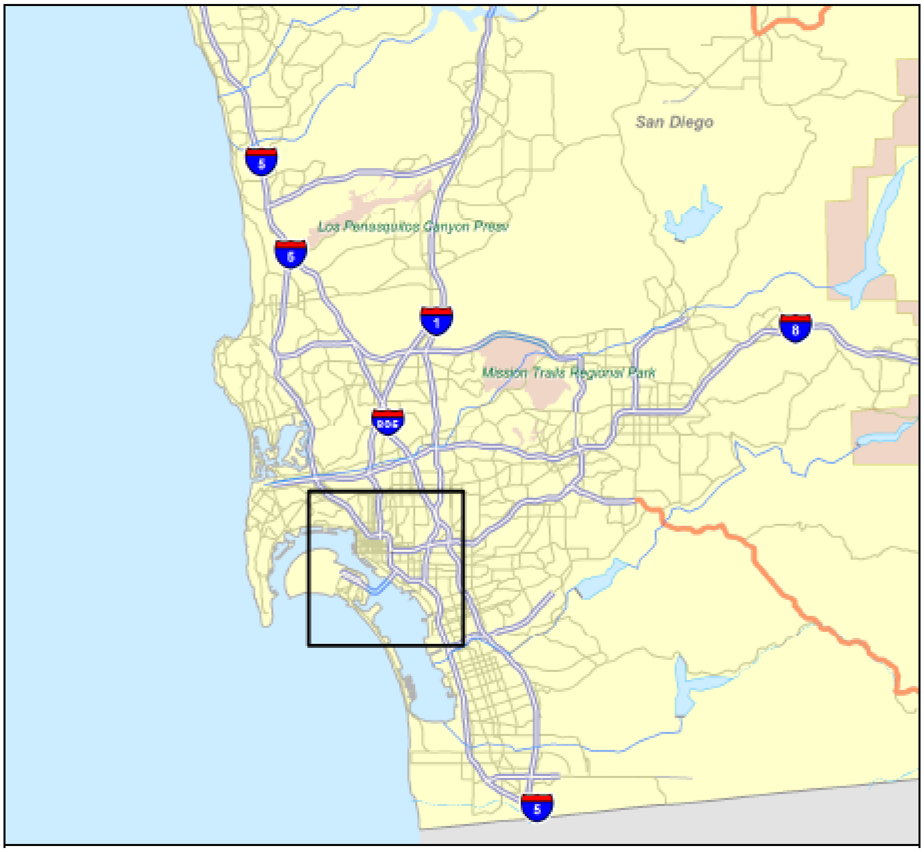


Figure 1 illustrates the region surrounding the BNSF San Diego Railyard modeling domain. The domain has dimensions 11 km x 11 km and contains a grid of 530 receptors with a 500 meter uniform grid spacing.

Figure 2: BNSF San Diego Railyard Urban Population

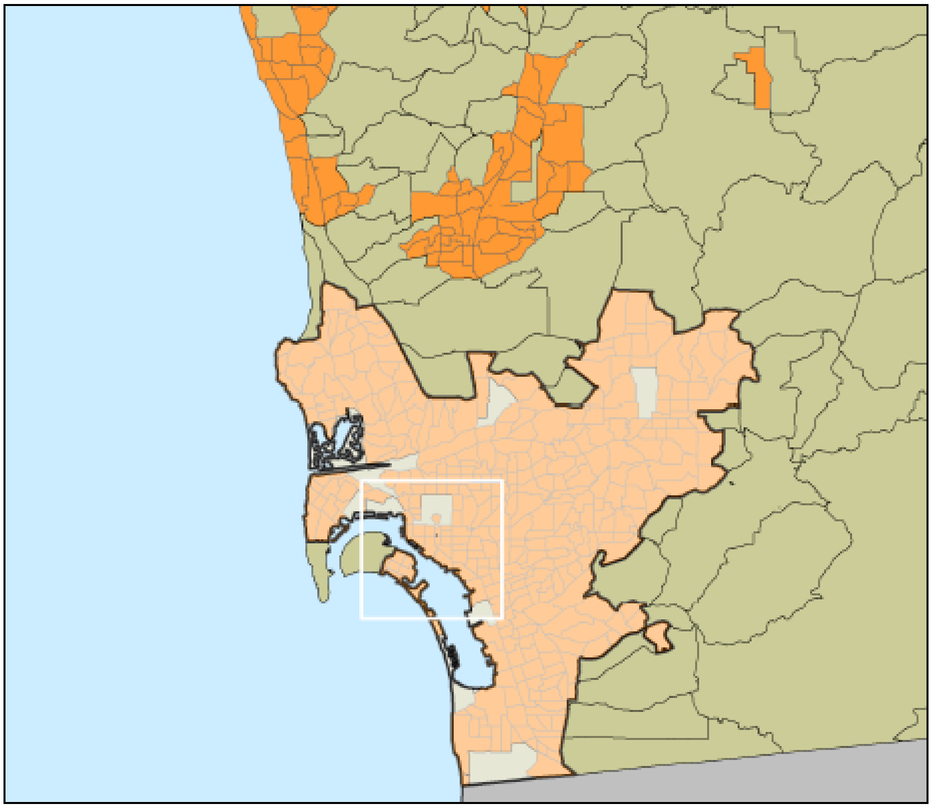
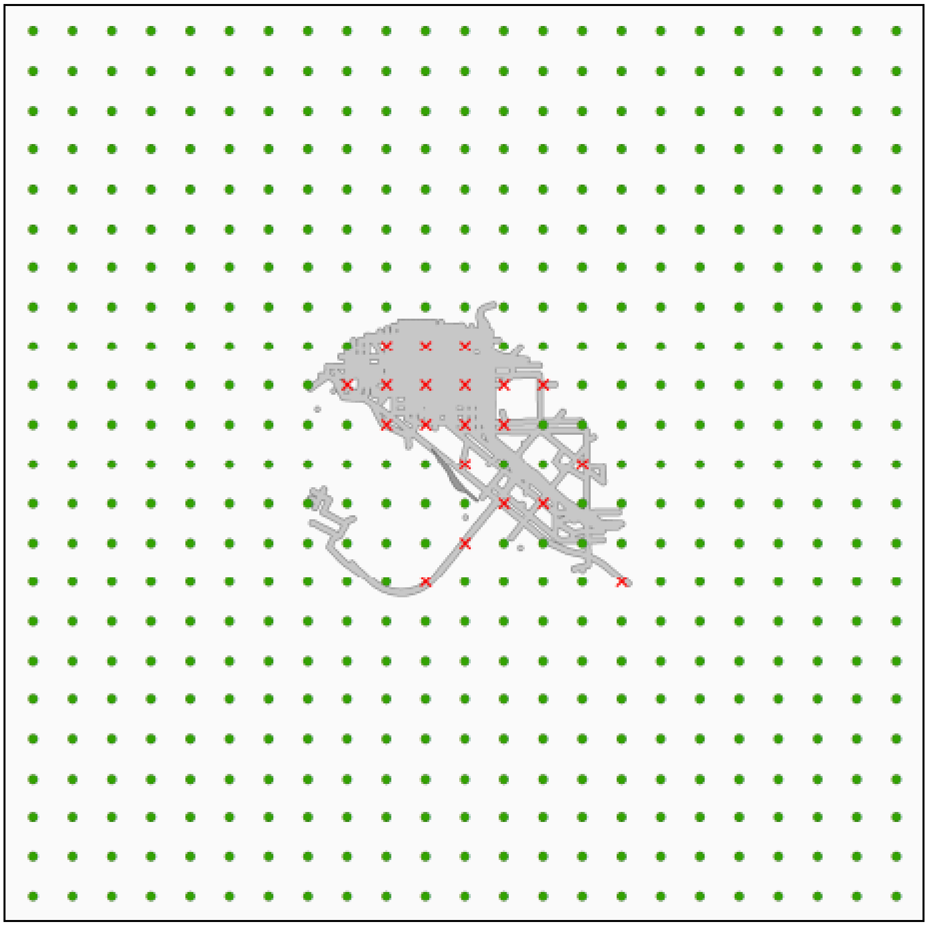


Figure 2 shows the urban population for San Diego. Orange (dark if printed in black and white) denotes areas with at least 750 people/km^2. The highlighted region is the contiguous urban area used for modeling purposes.

AERMOD requires an estimate of the urban population for urban source modeling. The urban population parameter was determined by estimating the area of continuous urban features as defined by the model guidelines (AERMOD Implementation Guide September 27, 2005). According to the guidelines, areas with a population of at least 750 people per square kilometer are considered urban. The BNSF San Diego Railyard model domain is in a region with considerable urbanization. The continuous urban area selected can be seen in Figure 2. The population in this selected area is 1,607,323.

Figure 3: BNSF San Diego Railyard Receptor Network (Including Off-Site Sources and Railyard Facility)



The off-site stationary and on-road emission sources used in the BNSF San Diego Railyard model runs are plotted along with the receptor network in Figure 3. These sources do not represent all stationary and roadway sources within the domain, but rather a subset made up of those roadways and facilities within one mile of the perimeter of the railyard facility. Diesel PM off-site emissions used in the offsite modeling runs consisted of 6.0 tons per year from roadways and 5.6 tons per year from stationary facilities, representing emissions for 2005. Roadway emissions were simulated as AERMOD area sources with an aspect ratio of no greater than 100 to 1, with a width of 7.3 meters and a release height of 4.15 meters.

As indicated above, Figure 3 illustrates a 11 km x 11 km gridded receptor field with uniform 500 meter spacing of receptors that are plotted as "●". Because a uniform grid sometimes places receptors on a roadway, those within 35 meters of a roadway were omitted. The basis for this is that these receptors are likely to fall on the roadway surface, versus a dwelling or workplace, and have high model-estimated concentrations, which could skew average concentration isopleths. Locations where receptors were removed are displayed as an "**x**" in Figure 3. After removal, 510 of the original 530 receptors remained.

The same meteorological data used by ENVIRON were used for the offsite modeling runs. The data were compiled by ENVIRON from the San Diego-Beardsley Station (32° 42' 6" N, 117° 8' 59" W). Upper air data for the same time period were obtained from the San Diego Miramar upper air station (32.83° N, 117.12° W). The model runs used one year of meteorological data from 2006.

Figure 4: BNSF San Diego Railyard Off-Site Sources and Railyard (Modeled Annual Average Off-Site Source Concentrations in μg/m^3)

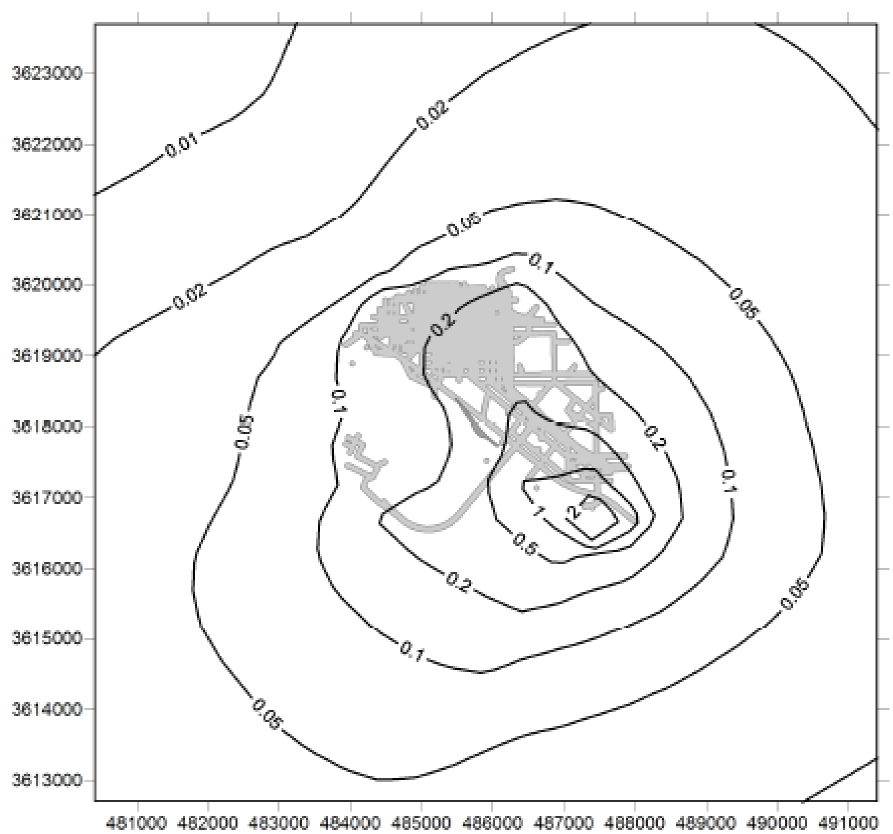


Figure 4 shows annual average diesel PM concentrations from the off-site emissions. Highest values occur near major freeways; the five highest concentrations at a receptor and their locations are provided in Table 2.

Table 2: BNSF San Diego Railyard
Maximum Annual Concentrations (µg/m^3)

X	Y	Mobile	Stationary	Total Off-site
487400	3616700	0.075	4.151	4.226
487400	3617200	0.262	1.069	1.331
486900	3616700	0.089	1.078	1.166
486900	3617200	0.197	0.871	1.068
486400	3617200	0.153	0.870	1.023

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APPENDIX D

LOCOMOTIVE DIESEL PM EMISSION FACTORS

Locomotive Model Group	Cert Tier[a]	Emission Factors (g/hr) by Throttle Notch									
		Idle	DB[b]	1	2	3	4	5	6	7	8
Switchers (1)	Precntl	31.0	56.0	23.0	76.0	131.8	146.1	181.5	283.2	324.4	420.7
GP-3x (1)	Precntl	38.0	72.0	31.0	110.0	177.7	194.8	241.2	383.4	435.3	570.9
GP-4x (1)	Precntl	47.9	80.0	35.7	134.3	216.2	237.5	303.5	507.4	600.4	771.2
GP-50 (1)	Precntl	26.0	64.1	51.3	142.5	288.0	285.9	355.8	610.4	681.9	871.2
GP-60 (1)	Precntl	48.6	98.5	48.7	131.7	271.7	275.1	338.9	593.7	699.1	884.2
SD-7x (1)	Precntl	24.0	4.8	41.0	65.7	149.8	223.4	290.0	344.6	446.8	553.3
Dash-7 (1)	Precntl	65.0	180.5	108.2	121.2	322.6	302.9	307.7	268.4	275.2	341.2
Dash-9 (2)	Precntl	32.1	53.9	54.2	108.1	197.3	267.3	343.9	392.4	397.3	573.3
EMD 12-710G3 (3)	Precntl	27.5	54.5	34.0	112.5	186.6	216.8	270.1	379.3	445.4	591.0
GP-60 (4)	0	21.1	25.4	37.6	75.5	228.7	323.6	467.7	666.4	1058.5	1239.3
SD-7x (1)	0	14.8	15.1	36.8	61.1	220.1	349.0	407.1	796.5	958.1	1038.3
Dash-8 (1)	0	37.0	147.5	86.0	133.1	261.5	271.0	304.1	334.9	383.6	499.7
Dash-9 (5)	0	33.8	50.7	56.1	117.4	205.7	243.9	571.5	514.6	496.9	460.3
Dash-9 (4)	1	16.9	88.4	62.1	140.2	272.8	354.5	393.4	466.4	445.1	632.1
ES44/Dash-9 (4)	2	7.7	42.0	69.3	145.8	273.0	337.4	376.0	375.1	419.6	493.5

(1) Final locomotive emission factors (an update to the Roseville study emission factors Table B-1) received via email from Dan Donohue of ARB, May 9, 2006.
(2) “Diesel Fuel Effects on Locomotive Exhaust Emissions,” Southwest Research Institute, October 2000.
(3) “Locomotive Emission Standards”, Regulatory Support Document, U.S. EPA, Office of Mobile Sources, April 1997
(4) Confidential data from Southwest Research Institute (SwRI), 2005.
(5) Average of ARB and SwRI, 2005.
[a] Precntl: Precontrolled
[b] DB: Dynamic Braking

APPENDIX E

SPATIAL ALLOCATIONS OF MAJOR DIESEL PM EMISSION SOURCES AT BNSF SAN DIEGO RAILYARD

Figure E-1: Spatial Allocation of Locomotive Emissions at BNSF San Diego Railyard.

APPENDIX F

AERMOD MODEL SENSITIVITY ANALYSIS OF METEOROLOGICAL DATA (ONE- VS. FIVE-YEAR DATA)

Figure F-1 AERMOD's Simulated Diesel PM Concentrations (due to On-site and Off-site Diesel PM Emissions) Around UP Stockton Railyard, Using One Year of Meteorological Data

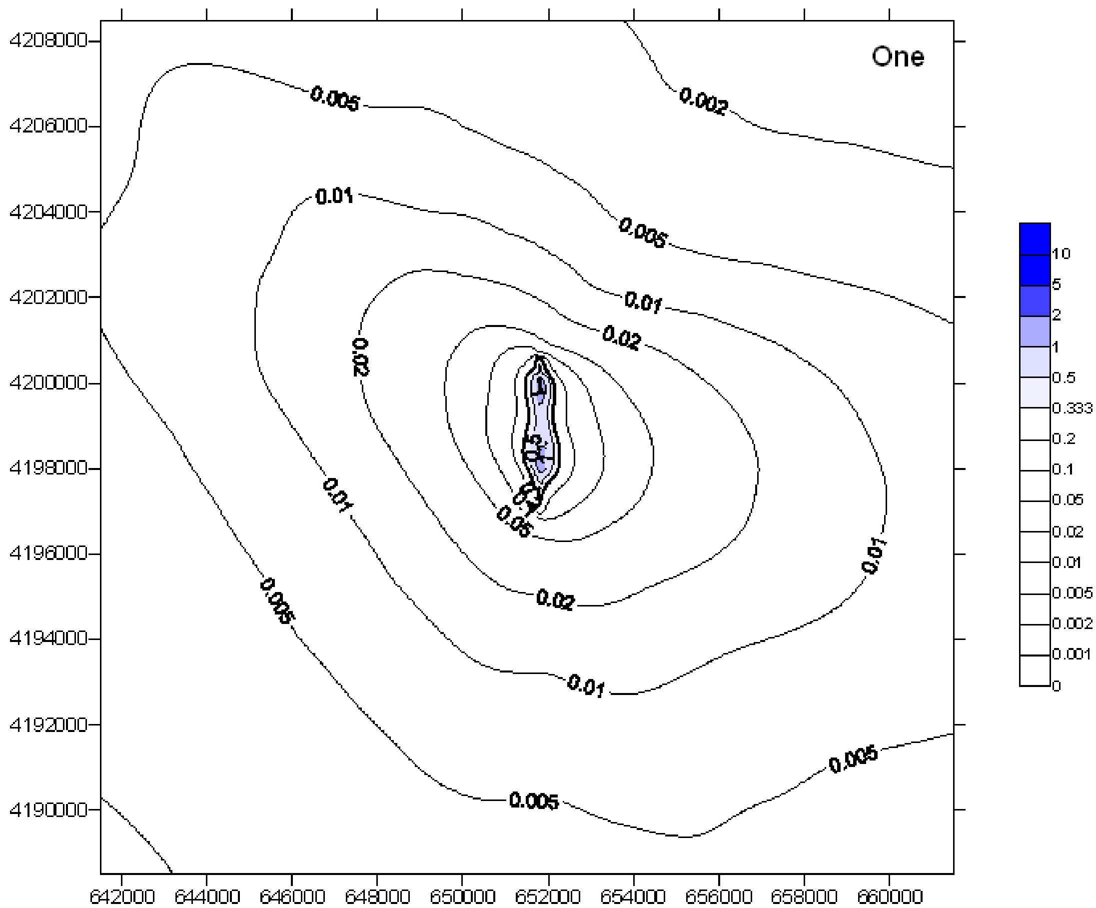

Figure F-2 AERMOD's Simulated Diesel PM Concentrations (due to On-site and Off-site Diesel PM Emissions) around UP Stockton Railyard Using Five-year Meteorological Data.